

# The American Midland Naturalist

Founded by J. A. Nieuwland, C.S.C.

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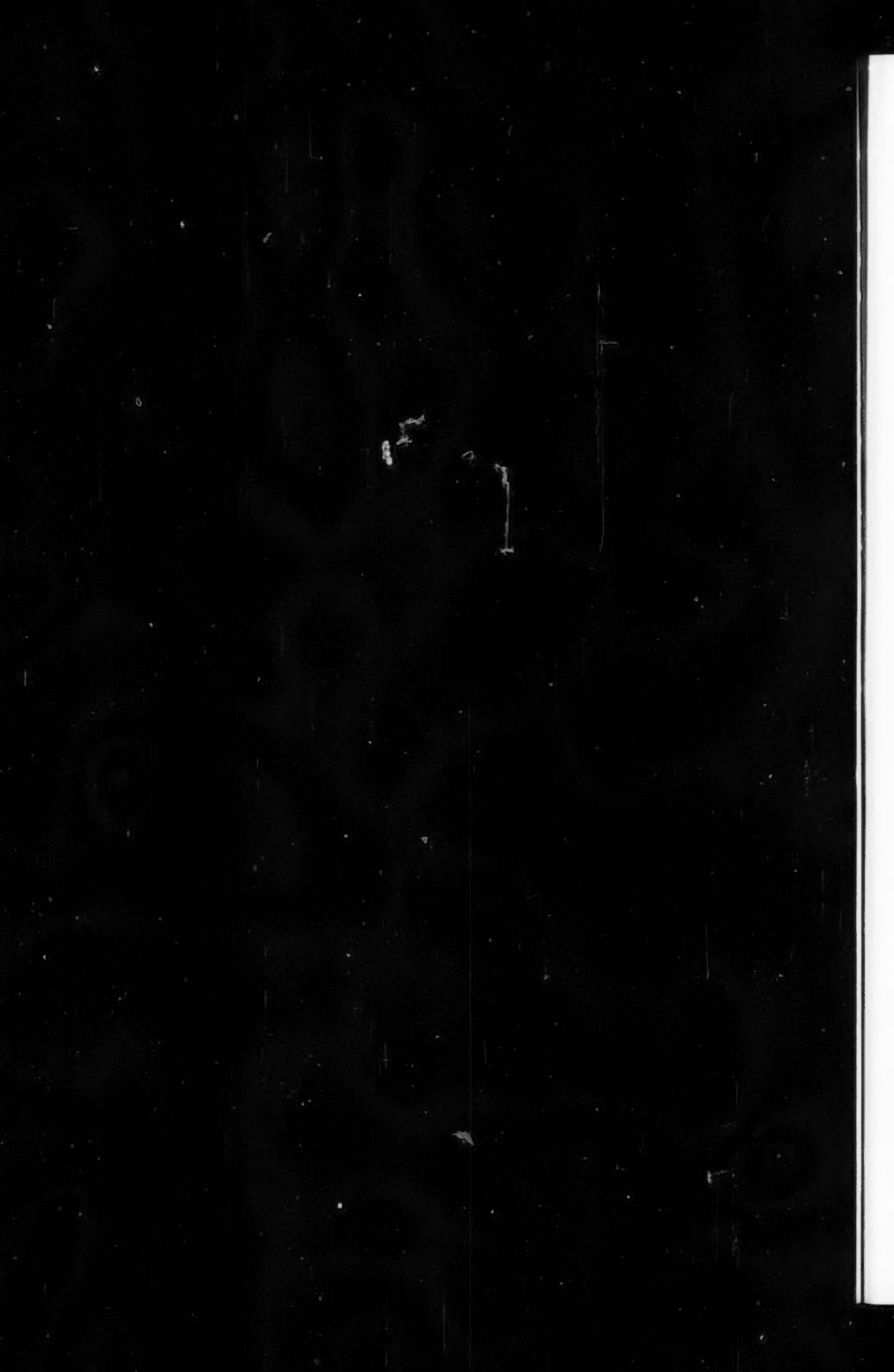
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# The American Midland Naturalist

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No. 1

## Records and Descriptions of North American Crane-Flies (Diptera)<sup>1</sup>

### Part VII. The Tipuloidea of Utah, I

Charles P. Alexander  
*University of Massachusetts, Amherst*

#### General Account

In our continuing survey of the crane-flies of western North America, the State of Utah assumes great importance from its strategic geographical position between the Rocky Mountains on the east and the Sierra Nevada to the west.

Utah is nearly rectangular in outline, being 345 miles from north to south and 275 from east to west, the area totalling 84,970 square miles, of which 2,806 is water. The national forest holdings in the State include nearly 8,000,000 acres. All of the drainage is to the west of the Continental Divide.

Alter (in *Climate and Man*, 1941) provides the following comprehensive summary:

"The general elevation of Utah is about 5,500 feet above sea level, though the Wasatch and Uinta Mountains extend diagonally across the State from southwest to northeast, with crest lines mostly above 10,000 feet. Minor mountains are scattered over the rest of the State, though the flatter part of the Great Salt Lake drainage basin is below 4,500 feet in elevation, the lake being about 4,215 feet. The lowest area in the State is the Virgin River Valley in the extreme southwestern part, its elevation being between 2,500 and 3,500 feet.

"Practically the entire area east of the Wasatch Mountains is drained by the Green and Colorado Rivers, the State's largest streams, though neither rises within its borders. Western Utah is almost entirely within the Great Basin, without outlet to the sea. The largest rivers are the Bear, Weber (and Ogden) and Provo, all emptying into Great Salt Lake (the Provo through Utah

<sup>1</sup> The preceding part under this general title was published in *The American Midland Naturalist* 35:484-531, 1946.

References in the text refer to the bibliography at the conclusion of the general account.

In all cases in this report where no collector is given, the specimens were secured by the author. M. M. Alexander—Mrs. Charles P. Alexander.

Lake and Jordan River). Sevier River drains the west-central counties and empties into Sevier Lake, a brackish saline basin, when its waters are not wholly withdrawn for irrigation purposes.

"The average annual precipitation for the State is about one-third that of the Middle Western or Eastern States generally, necessitating the practice of irrigation for growing farm crops. But the mountains, whose winter snows form the chief reservoirs, are conveniently adjacent to practically all the farming regions, and there is usually an abundance of water for all lands under irrigation. The bulk of the moisture falls in late winter and spring in the State's leading agricultural areas. The summer and early fall months are almost invariably the driest."

The Uinta Mountains, largest east-west range in the entire United States, some 150 miles long and 30 to 40 miles wide, has some peaks that are more than 13,000 feet high, including the highest point in Utah, King's Peak, 13,498 feet, on the southern border of Summit County.

*Biotic and Physical Provinces.*—Of the various biotic provinces in North America as recognized by Dice (1943), four are found in Utah, three chiefly in the desert and semi-desert portions of the State. The Artemesian or Great Basin Province includes the western third of Utah, then extending westward to involve almost all of Nevada, with extensive adjoining sections of northeastern California and southern Oregon and Idaho. The Navahonian Province, eminently characteristic of much of northern Arizona and New Mexico, involves the southeastern third of Utah. In the northeastern portion of the State, including the Wasatch and Uinta Mountains, is found the Coloradan Province, extending westward from its major center in Wyoming and Colorado. In the extreme southwest, in the vicinity of St. George and the Virgin River, is found a small northeastern extension of the Mohavian Province from the major area in the adjoining desert areas of Nevada, California and Arizona. The general distribution of the Tipulidae in Utah seems to confirm the distinctness of these four areas.

The Fenneman (1931) classification of Utah into physical divisions is very similar to the last, the western third of the State lying in the Great Basin Section of the Basin and Range Province; more than the eastern half is occupied by the Colorado Plateaus Province, with the High Plateaus Section extending down the central portion of the State, the Uinta Basin Section in the northeast, and the Canyon Lands Section in the southeast. In the extreme northeastern portion of Utah a third major area occurs, the Middle Rocky Mountains Province, including the Wasatch and Uinta Mountains.

Mulford, in Van Dersal (1938), classifies the United States on the basis of plant-growth regions, soil regions and climatic provinces, with detailed maps. For Utah, the Snake River Plain-Utah Valley plant growth region in the northwest is arid, microthermal and is deficient in precipitation at all seasons. The Great Basin-Intermontane plant growth region, chiefly in the southwestern, southern and eastern portions of the State, ranges from semi-arid to arid, is microthermal and shows moisture deficiency at all seasons. In the Central Rocky Mountain plant growth region, in the northern portion of the Central Plateaus, conditions are sub-humid, microthermal and with a

summer deficiency of precipitation; in the southern portion, conditions are semiarid, microthermal and with a deficiency of moisture at all seasons. In the Wasatch and Uinta Mountains, the climatic provinces range from humid to sub-humid, are microthermal and with a summer deficiency of moisture; on the higher crests of the Uintas, taiga conditions prevail.

*Life Zones.*—In general, the distribution of life zones in Utah appears to be very much as in Colorado, as defined by Cary (1911: 14), as follows:

*Northern Colorado* (heights in feet; exp.—exposure).

Upper Sonoran to 5600, NE exp.; to 6500, SW exp.  
Transition 5600-7500, NE exp.; 6500-8200, SW exp.  
Canadian 7500-10,000, NE exp.; 8200-10,400, SW exp.  
Hudsonian 10,000-10,900, NE exp.; 10,400-11,600, SW exp.  
Arctic-Alpine 10,900 up, NE exp.; 11,600 up, SW exp.

*Southern Colorado*

Upper Sonoran to 6500, NE exp.; to 7800, SW exp.  
Transition 6500-8000, NE exp.; 7800-9000, SW exp.  
Canadian 8000-10,500, NE exp.; 9000-11,000, SW exp.  
Hudsonian 10,500-11,200, NE exp.; 11,000-12,000, SW exp.  
Arctic-Alpine 11,200 up, NE exp.; 12,000 up, SW exp.

For Zion National Park and vicinity, the special treatments on life zones by Presnall (1938), Presnall and Patraw (1937) and Woodbury (1933) may be consulted. Presnall (1938: 2-3), by description and diagram, indicates that the Lower Sonoran (Lower Austral) occurs up to 4000 feet; Upper Sonoran (Upper Austral), 4000—7000 feet; Transition, 7000—8500 feet; Canadian, 8500—10,000 feet; Hudsonian, above 10,000 feet (at Cedar Breaks). The occurrence of more northern types in suitable situations in lower zones in the park has been discussed further under "Collecting Stations," later in this introductory account.

### General Survey of the Tipuloidean Fauna of Utah

As a result of the intensive efforts of Professor Knowlton and the writer, with the co-operation of many other entomologists, our knowledge of the crane-flies of Utah must be considered as having reached a point where it is better known than any other of our Rocky Mountain and Great Basin States. Virtually all of the species hereinafter recorded had not been reported for the state. Despite this impressive basic list, there will undoubtedly be found many further species and it seems very possible that the complete record for the state may well reach 250 species or even more.

In the present report, 187 species are recorded, well represented in the families, subfamilies and tribes of the Nearctic Region. To date, no member of the subfamily *Cylindrotominae* has been found in Utah but this is due certainly to insufficient collecting in the northeastern section of the state. The genus *Tipula*, with 51 species, is noteworthy. The small tribe *Pediciini*, eminently characteristic of northern conditions, is well represented. In the subfamily *Limoniinae*, by far the most abundant tribe within the state is the *Eriopterini*, with a host of small and medium-sized forms that include more than one-third the total crane-fly fauna. Of special interest is the great development of the genus *Gonomyia*, represented by no fewer than 18 species, a

number that is equal to the entire northeastern North America and far exceeding the total for any other state of the union, as at present known.

*Collecting Stations.*—The writer and Mrs. Alexander spent the period between June 21 and 30, 1942 in Utah entering the state from the south at Kanab, following a visit to the Kaibab Plateau in northern Arizona. Our collections, although large, thus were restricted to the last few days of June, in the high mountains representing the spring fauna only, and were quite insufficient for making any comprehensive study of the crane-flies of the state. Most fortunately, such materials have been added to vastly by the great series of specimens made over the past several years and in virtually every section of Utah by Professor George F. Knowlton and his co-workers at Logan. Further acknowledgement of Professor Knowlton's efforts to make known the Tipulid fauna of the state is made later in this general account. Although our own collections were made at intervals along our route in Utah, four places proved to be of such interest and importance as to warrant the establishment of special study stations, where, it is hoped, detailed seasonal studies may be continued in the future. The four stations established by Mrs. Alexander and me in 1942 are as follows:

1. Zion National Park. A vast gorge in the southwestern part of Utah, some 45 miles from the border of Nevada and 15 from Arizona; all collections of Tipuloidea were made in Washington County. The Zion Canyon has been formed primarily by the action of the north fork of the Virgin River (Mukuntuweap River) which flows down the steep southern slopes of the Markagunt Plateau, in a distance of some 40 miles dropping from altitudes of about 10,000 feet on Cedar Mountain to 7000 feet on the plateau through which the canyon is cut and to 3500 feet below the mouth of the gorge. Woodbury (1933) states that "The canyon is about 20 miles in length, running in a general direction slightly west of south. It varies in width from a slit just wide enough for the river in the narrows, gradually widening downstream to a mile or more across the floor near the mouth of the canyon where the town and fields of Springdale are located." A detailed topographic map of the park is available (Gregory and Evans, 1936).

The park is a wonderful spot, surprisingly rich in Tipulidae, particularly when contrasted with the nearby Bryce National Park, where these flies are exceedingly uncommon or do not occur. There are several important references that consider the fauna and flora of Zion and provide more or less detailed accounts of the geology, climate, biota and life zones (as Gregory, 1941; Presnall, 1938; Presnall and Patraw, 1937; Tanner, 1928; Woodbury, 1933). The very important paper by Woodbury should be consulted for many data concerning the climate, geology and biology of the area.

A brief statement from Gregory (1941: 3; Gregory and Evans, 1936) presents a picture of the conditions obtaining in the park. "In Zion National Park the annual rainfall ranges from 10 to 20 inches and the temperature from 10° to 105° Fahr. The winters are short and mild; the summers long and hot. Though varying greatly from year to year, month to month, and even day to day, the precipitation is so distributed as to produce two wet cycles, one in winter and early spring and one in late summer, and two dry

cycles, one in late spring and early summer and one in late fall. In response to these conditions many species of plants complete their life cycle before June, and others begin their cycle in late summer and complete it in the fall. Beginning early in May the spring cycle is the time for violets, orchids, pentstemons, sego lily, and in shady nooks the columbine and monkey flower. During the excessive heat of summer, day-blooming plants are largely replaced by such night-blooming species as evening primrose, four o'clock, spiderwort, and the glorious sacred datura—a veritable 'moonlight garden'. During the late summer cycle the roads pass through fields of asters, sunflowers, bee flowers, Indian paint brush, and sweet clover, and the cool shady nooks are made brilliant by the cardinal flower. There is little evidence of any zonal distribution of plants based on latitude or the equivalent altitude. The range in kinds of soil, exposure to the sun, and amount of ground water is so great that indigenous plants of the Lower Sonoran, Upper Sonoran, Transition, and even Canadian zones, together with most migrating plants, find favorable habitats. On the floor of the canyon are groves of boxelder, willow, cottonwood, and ash." There follows a further consideration of the plants of the slopes and terraces at higher altitudes that have not yet been studied as regards the Tipulidae.

All collections made in Zion by Mrs. Alexander and the writer pertain to the bottom of the canyon, within a few hundred feet of the altitudinal level of the Virgin River and all nominally in the Upper Sonoran (Upper Austral) life zone. However, the occurrence of more northerly "islands" in various places should be emphasized. As stated by Presnall and Patraw (1937: 4): "The most noticeable of these variations is to be seen in the bottom of nearly every canyon, where much moisture and shade favor the growth of Transition or even Canadian Zone species, no matter what may be the actual altitude. In canyons where water seeps continually from the cliffs there are great 'hanging gardens' of ferns and other plants that would normally be found at a much higher altitude. The Narrows is the classic example of this, but dozens of other canyons have the same type of vegetation."

The great majority of the Tipulidae so far taken at Zion have been collected at or near these "hanging gardens", especially at the Weeping Rock and in the Narrows. As discussed by Gregory (1941:17): "The evidence is clear that the canyon alcoves are the work of rain that falls directly into them and of underground water that seeps out through their walls. The process is sapping and undermining rather than excavation. The cliff walls of sandstone are undercut by the removal of soft shales beneath, and in response to gravity fragments fall off. The walls retreat and the rim develops curves and crenulations chiefly in consequence of erosion at their bases. Thus at Wiley Retreat, the Grotto, Weeping Rock, and other prominent alcoves part of the rain water that falls on the upland passes downward through porous rock until it reaches impervious beds and finally reaches the surface as springs and seeps. On emerging, these underground waters carve horizontal grooves in the canyon walls, leaving overhanging cliffs above and a slope below. Into the slope perennial streams from the spring are cutting channels that lead to the Virgin River."

The cliffs that support the rank growth of vegetation called the "hanging

gardens" are of travertine, or calcareous tufa, produced by the springs of water percolating through the sandstone and forming calcium carbonate. The water finally emerges as a constant seeping or dripping, or, in places, as a shower of spray or as small waterfalls. In such continually wet places, a rich vernal flora and associated crane-fly fauna is to be found. In the open alcoves, as at Weeping Rock, the cliff walls are sunlit for much of the day but the actual rock faces are more or less shaded by the luxuriant growth of herbage and provide ideal haunts for several species of Tipulidae. In the Narrows, where the canyon decreases about to the width of the Virgin River, a mere 20 feet, with virtually sheer walls some 2000 feet high, the cliff faces are more cool and shaded and the plant growth even more rank and luxuriant. In June, almost the dominant plant species is the Venushair fern, *Adiantum capillus-veneris* Linn., forming great draperies over the rocks. Associated species of higher plants are many, including *Smilacina liliacea* (Greene); two showy species of columbine, *Aquilegia rubicunda* Tidestrom and *A. thalictrifolia* Rydberg; shootingstar, *Dodecatheon pauciflorum* (Durand); and the monkeyflower, *Mimulus cardinalis* Douglas, and several others. Young plants of cardinal flower, *Lobelia cardinalis graminea* (Lam.) occur. The commonest liana along the streams is poison-ivy, *Rhus rydbergii* (Small).

Certain crane-flies are strictly aquatic in their larval stage and inhabit streams of the general nature and appearance of the Virgin River. The latter seems to be surprisingly poor in such strictly aquatic forms, the reason presumably being as given by Woodbury (1933) in his discussion of the Virgin River, which he describes as being an "Aquatic Desert", due to the scarcity of life forms in the stream proper. The tremendous periodic floods that sweep down the valley seem to keep the stream bed scoured clean, even diatoms and other algae having difficulty in maintaining an existence. It might be observed that a species of net-winged midge, Blepharoceridae, genus *Blepharocera*, occurs along the river at the Narrows and is evidently able to withstand the scouring action.

Crane-fly collecting at both the Weeping Rock and the Narrows proved most exciting and productive. Mrs. Alexander and I camped in Zion between June 21 and 23, 1942. Professor Knowlton and colleagues have supplemented such collections by materials taken on various trips to the Park covering a much wider range of dates. On July 1-3, 1942, Dr. Otto Degener and Mr. Leroy Peiler secured a few further interesting Tipulidae in the Park.

Among the more interesting Tipuloidea taken in Zion are the following: *Protanoderus margarita*\*, *Holorusia grandis*, *Tipula* (*Bellardina*) *schizomera*, *T.* (*Yamatotipula*) *meridiana*, *Limonia* (*Dicranomyia*) *brevivena*, *L.* (*Geranomyia*) *canadensis*, *L.* (*G.*) *diversa*, *L.* (*G.*) *parapentheres*\*, *L.* (*G.*) *zionana*\*, *Orimarga* (*Orimarga*) *zionensis*\*, *Oxydiscus* (*Oxydiscus*) *maddocki*\*, *Phyllobasis* *zionensis*\*, *Teucholabis* (*Teucholabis*) *rubescens*, *Gonomyia* (*Progonomyia*) *zionicola*\*, *G.* (*Idiocera*) *multistylata*\*, *G.* (*I.*) *coloradica*, *G.* (*Lipophleps*) *cinerea*, *G.* (*Gonomyia*) *paiuta*\*, *G.* (*G.*) *spinifer*, *Rhabdomastix* (*Sacandaga*) *californiensis*, *R.* (*S.*) *ioogoon*\*, *R.* (*S.*) *leonardi*, *R.* (*S.*) *lipophleps*\*, *Cryptolabis* (*Cryptolabis*) *sica*\*, *Erioptera* (*Psiloconopa*) *margarita*, *E.* (*P.*) *neomexicana*, *E.* (*P.*) *sinawava*\*, *E.* (*Mesocyphona*) *eiseni*,



and others. The species marked with an asterisk\* were new to science when first discovered at this station. Labelled "Zion National Park."

2. Sevier River, near Hatch, southwestern Garfield County, altitude estimated at about 6700 feet, June 23, 1942. Collections swept from grasses and *Equisetum* growing among low willows along the river. Vast sagebrush plains occur on both sides of the stream but all collecting was from the more humid strip close to the water. Several Tipulidae occurred, including *Gonomyia* (*Gonomyia*) *sevierensis*\*, *Erioptera* (*Psiloconopa*) *margarita* Alexander, *E. (P.) megarhabda* (Alexander), *Molophilus* (*Molophilus*) *colonus* Bergroth, and others. Labelled "Sevier River."

3. High-Lowe Creek and Pond, in mountains above Beaver, Fishlake National Forest, Beaver County; altitude 8,000 feet, June 25—26, 1942. A swift-flowing mountain stream, dammed by beavers to form a small pond below the road. Collecting along the stream above the pond for a distance of about 100 yards only but very minutely surveyed. The sparse forest cover consists of ponderosa pine, *Pinus ponderosa* Douglas; blue spruce, *Picea pungens* Engelm.; Douglas-fir, *Pseudotsuga taxifolia glauca* Mayr; white fir, *Abies concolor* (Gordon & Glendinning); aspen, *Populus tremuloides* Michx., together with scattered juniper and willow. The rank streamside herbage included various species of crucifers, together with species of *Smilacina*, *Urtica*, *Geranium*, *Geum*, *Rosa*, *Osmorrhiza*, *Mertensia*, and others. The white form of the Colorado columbine, *Aquilegia coerulea pinetorum* Tidestrom, was very common and several of the Tipulidae were found resting on these plants. The stream was cold (49° Fahr. at noon) and crystal clear, with numerous small falls and riffles. The air temperature at 7 A.M., June 26th, was 38° Fahr. The humid environment so preferred by the Tipulidae was entirely restricted to and created by the stream. Twenty feet away arid conditions began and sagebrush gradually became abundant.

Tipulidae were numerous and interesting, including among others, *Tipula* (*Schummelia*) *magnifolia*\*, *T. (Yamatotipula) meridiana*, *T. (Y.) spernax*, *Pedicia* (*Tricryphona*) *exoloma*, *Dicranota* (*Rhaphidolabis*) *neomexicana*, *Limnophila* (*Elaeophila*) *aldrichi collata*\*, *L. (Phylidorea) claggi*, *L. occidentis*, *Gonomyia* (*Gonomyia*) *bihamata*, *Ormosia* (*Rhypholophus*) *bifidaria*, *O. (Ormosia) albertensis*, *O. (O.) defrenata*\*, *O. (O.) fusiformis*, *O. (O.) spinifex*, *Erioptera* (*Psiloconopa*) *gaspicola*, *E. (Hesperoconopa) dolichophallus*\*, *E. (Mesocryphona) distincta*, and others. Labelled "Beaver."

4. Logan Canyon, along the Logan River, in Cache National Forest, Cache County; collecting done in the Lodge Forest Campground, Preston Valley Campground, China Row, and higher up the canyon, between 4800 and 5200 feet, June 29th and 30th, 1942. Logan Canyon is one of the favorite collecting, camping and picnicking spots for the entomologists stationed at Logan. The stream and its environment are magnificent and undoubtedly many further discoveries in the Tipuloidea will be made here. Particular attention is called to the report by Needham and Christenson (1927) on "Economic insects in some streams of northern Utah", where a detailed study of the Logan River is recorded, based upon collecting done in the summer of 1926, with the base station at Birch Glen, in the heart of the Canyon.

Tipulidae secured by us included *Ptychoptera pendula*, *Tipula* (*Bellardina*) *commiscibilis*, *T.* (*Schummelia*) *subtenuicornis*, *T.* (*Yamatotipula*) *albocaudata*, *T.* (*Lunatipula*) *splendens*, *Antocha* (*Antocha*) *monticola*, *Dicranota* (*Rhaphidolabis*) *cayuga*, *Limnophila* (*Elaeophila*) *angustior*, *L. bigladi*, *Hexatoma* (*Eriocera*) *eriophora*, *Ormosia* (*Ormosia*) *brachyrhabda*\*, *Erioptera* (*Psiloconopa*) *microcellula*, *E.* (*Hesperoconopa*) *aperta*, *Molophilus* (*Molophilus*) *perflaveolus*, and others. Particular attention should be called to the strictly aquatic *Antocha* which is certainly the most characteristic single species of this family along this river. Labelled "Logan Canyon."

*Collectors and Localities.*—As indicated earlier, the primary basis for the present report is the large collection made by Professor Knowlton and associates at Logan. Since a great many collectors are included in the report, it seems advisable to list these alphabetically. In the main body of the report, the very numerous records made by Knowlton have been abbreviated to the letter "K"; where no collector is given it may be understood that the specimens (all 1942) were taken by the writer. The asterisk indicates the more important collectors.

- |                                |                      |
|--------------------------------|----------------------|
| Aldous                         | *Mulaik, Stanley B.  |
| Ashdown, D.                    | Needham, J. G.       |
| Bates, R. C.                   | Nye, William P.      |
| Bischoff, L. D.                | *Peay, W. E.         |
| *Degener, Otto                 | Peiler, Leroy        |
| Duncan, B.                     | *Rees, B. E.         |
| *Edmunds, George F.            | Rees, Don M.         |
| Fechser, John C.               | Rees, H. D.          |
| Frahm, W. A.                   | Roberts, R. S.       |
| Gauflin, A.                    | Rowe, J. A.          |
| Hagan, H. R.                   | Sargent, K. & D. L.  |
| Hammond, D. M.                 | Smith, C. F.         |
| Hansen,                        | *Spalding, Thomas U. |
| Hardy, Agnes T.                | Stafford, Harold     |
| *Hardy, D. Elmo                | *Stains, G. S.       |
| Hardy, Horace                  | Stoddard, E. R.      |
| *Harmston, Fred C.             | *Tanner, Vasco M.    |
| Hayward, C. Lynn               | *Telford, P. E.      |
| Ivie, W.                       | Thatcher, Thomas     |
| Janes, K. & R. L.              | Tibbets, T. & M.     |
| *Knowlton, George F. & Mary W. | Tipton, Vernon       |
| Linford, J. H.                 | Van den Akter, J. G. |
| *Maddock, Darrell R.           | Wilson, K.           |
| McEwen, Harry                  | *Wood, Stephen L.    |
| Moffet, J. E.                  | Woodbury, Angus M.   |

Many of the western United States, including Colorado, Texas, New Mexico and Utah, in the earlier years of the present century had one or more professional insect collectors. For Utah, this was Thomas U. Spalding (Tanner, 1929) who made extensive collections in the state, chiefly between 1900 and 1925. His large and important series of Tipulidae were purchased by Dr. William G. Dietz and several new species were described from such materials, the collection now being preserved in the Academy of Natural Sciences, Philadelphia.

In order to avoid much repetition of data throughout the text it is be-



lieved that an alphabetical listing of the stations with the county and approximate altitude, where known, will prove helpful. Most of the altitudes have been taken from the American Guide Series volume on "Utah", cited in the References.

- Allen Canyon, Rich Co.  
 Alta, Little Cottonwood Canyon, Salt Lake Co., 8583 ft.  
 Alton, Kane Co., 6875 ft.  
 Amalga, Cache Co., 4555 ft.  
 American Fork Canyon, Utah Co.  
 Appledale, Box Elder Co., 4350 ft.  
 Arches National Monument, Grand Co.  
 Aspen Grove, on Mt. Timpanogos, 7000 ft.  
 Avon Canyon, Cache Co.
- Bear Canyon Camp, Mt. Nebo, Juab Co.  
 Bear Lake, Rich Co., 5925 ft.  
 Bear River City, Box Elder Co., 4255 ft.  
 Beaver, Beaver Co., 5970 ft.  
 Beaver, High-Lowe Camp (Alexander Stat. 3)  
 Beaverdam, Box Elder Co., 4340 ft.  
 Benjamin, Utah Co.  
 Benson, Cache Co., 4417 ft.  
 Big Cottonwood Canyon, Salt Lake Co.  
 Blacksmith Fork Canyon, Cache Co.  
 Blanding, San Juan Co.  
 Bloomington, Washington Co.  
 Blue Creek, Box Elder Co., 4660 ft.  
 Bluff, San Juan Co., 4320 ft.  
 Bothwell, Box Elder Co., 4325 ft.  
 Box Canyon, Sanpete Co.  
 Brigham, Box Elder Co., 4440 ft.  
 Brigham Canyon, Box Elder Co.  
 Brighton, Salt Lake Co.  
 Butterfield Canyon, Salt Lake Co.
- Cache Junction, Cache Co.  
 Callao, Juab Co.  
 Castilla, Utah Co.  
 Castle Valley, Grand Co.  
 Cedar Breaks, Iron Co.  
 Cedar City, Iron Co., 5805 ft.  
 Central, Washington Co., 5345 ft.  
 Charleston, Wasatch Co., 5435 ft.  
 China Row Camp, in Logan Canyon.  
 Circleville, Piute Co., 6060 ft.  
 City Creek Canyon, Salt Lake Co.  
 Clarkston, Cache Co., 4930 ft.  
 Clinton, Davis Co.  
 Coal Creek Canyon, Iron Co.  
 Coalville, Summit Co., 5570 ft.  
 Collinston, Box Elder Co., 4460 ft.  
 Corinne, Box Elder Co., 4230 ft.  
 Cornish, Cache Co.
- Cove (Cove Fort, Millard Co., 6000 ft.)  
 Currant Creek, Wasatch Co., 7200 ft.
- Daniels Pass, Wasatch Co.  
 Deer Creek (in Provo Canyon)  
 Delta, Millard Co., 4650 ft.  
 Devils Slide, Weber River, Morgan Co.  
 Draper, Salt Lake Co., 4525 ft.  
 Dry Canyon, Salt Lake Co.
- East Promontory, Box Elder Co.  
 Echo City, Summit Co., 5460 ft.  
 Eden, Weber Co., 4950 ft.  
 Elberta, Utah Co., 4660 ft.  
 Ephraim Canyon, Sanpete Co.,  
 Eureka, Juab Co., 6395 ft.
- Fairmont Park, Salt Lake City.  
 Fairview, Sanpete Co., 6035 ft.  
 Farmington, Davis Co., 4260 ft.  
 Farr West, Weber Co.  
 Ferron Reservoir, Sanpete Co.  
 Fillmore, Millard Co., 4995 ft.  
 Fish Lake, Sevier Co., 8600 ft.  
 Fish Springs, Juab Co.  
 Fort Duchesne, Uintah Co., 4990 ft.  
 Fountain Green, Sanpete Co., 5995 ft.
- Gandy, Millard Co.  
 Garden City, Bear Lake, Rich Co.,  
 5950 ft.  
 Garfield, Salt Lake Co., 4240 ft.  
 Garland, Box Elder Co., 4345 ft.  
 Glacier Lake, on Mt. Timpanogos  
 Glendale, Kane Co., 5825 ft.  
 Granite Creek, Juab Co.  
 Green River, Emery Co., 4080 ft.  
 Grover, Wayne Co., 6750 ft.
- Hanna, Duchesne Co., 6250 ft.  
 Hatch, Garfield Co.  
 Hayden, Uintah Co.  
 Heber, Wasatch Co., 5595 ft.  
 Henefer, Summit Co., 5340 ft.  
 Holden, Millard Co., 5115 ft.  
 Honeyville, Box Elder Co., 4270 ft.  
 Hooper, Weber Co., 4240 ft.  
 Howell, Box Elder Co.  
 Hoytsville, Summit Co., 5665 ft.  
 Huntington Canyon, Emery Co.,  
 6000-8000 ft.  
 Huntsville, Weber Co., 4920 ft.

- Hurricane, Washington Co., 3250 ft.  
 Hyde Park, Cache Co., 4450 ft.  
 Hyrum, Cache Co., 4705 ft.
- Ideal Beach, Bear Lake, Rich Co.  
 Indian Canyon, Duchesne Co.
- Johnson, Kane Co., 5000 ft.  
 Junction, Piute Co., 6250 ft.
- Kamas, Summit Co., 6475 ft.  
 Kanab Canyon, Kane Co.  
 Kanesville, Weber Co., 4275 ft.  
 Kanosh, Millard Co., 5125 ft.  
 Kaysville, Davis Co., 4295 ft.  
 Kents Lake, Beaver Mt., Beaver Co.  
 Kimballs Fort, Silver Creek, Summit Co.  
 Koosharem, Sevier Co., 6850 ft.
- Lake Point, Tooele Co., 4240 ft.  
 Laketown, Rich Co., 5990 ft.  
 Lakota, Bear Lake, Rich Co.  
 Layton, Davis Co., 4355 ft.  
 Leeds, Washington Co., 2750 ft.  
 Leeton, Uintah Co.  
 Lehi, Utah Co., 4550 ft.  
 Lewiston, Cache Co., 4505 ft.  
 Liberty, Morgan Co., 5110 ft.  
 Linwood, Daggett Co., 6025 ft.  
 Little Salt Lake, Iron Co.  
 Little Valley, Tooele Co.  
 Loa, Wayne Co., 7000 ft.  
 Logan, Cache Co., 4535 ft.  
 Logan Canyon, Cache Co.  
 (Alexander Stat. 4).  
 Logan Dry Canyon, Cache Co.
- Magna, Salt Lake Co., 4280 ft.  
 Manila, Daggett Co., 6375 ft.  
 Mantua, Box Elder Co., 5175 ft.  
 Maple Canyon, Sanpete Co.  
 Marriott, Weber Co.  
 Mendon, Cache Co., 4435 ft.  
 Midway, Wasatch Co., 5565 ft.  
 Mill Creek Canyon, Salt Lake Co.,  
 4475 ft.  
 Mirror Lake, Uintas, Summit Co.  
 Moab, Grand Co., 4000 ft.  
 Mona, Juab Co., 4915 ft.  
 Monroe Canyon, Sevier Co.  
 Monte Cristo, Weber Co.  
 Morgan, Morgan Co., 5065 ft.  
 Mountain Meadows, Washington Co.  
 Myton, Duchesne Co., 5085 ft.
- Nephi, Juab Co., 5095 ft.  
 Nibley, Cache Co., 4525 ft.  
 North Farmington, Davis Co.
- Oak Creek Canyon, Millard Co.,  
 5200 ft.  
 Oakley, Summit Co., 6515 ft.  
 Ogden, Weber Co., 4300 ft.  
 Orangeville, Emery Co., 5770 ft.  
 Orem, Utah Co., 4755 ft.
- Paradise, Cache Co., 4860 ft.  
 Parowan, Iron Co., 5990 ft.  
 Parrish Canyon (see Upper Parrish  
 Canyon).  
 Payson, Utah Co., 4700 ft.  
 Peoa, Summit Co., 6190 ft.  
 Peterson, Morgan Co., 4890 ft.  
 Pine Valley, Washington Co.  
 Pinto, Washington Co.  
 Plain City, Weber Co.  
 Pleasant Grove, on Mt. Timpanogos  
 Portage, Box Elder Co., 4370 ft.  
 Providence Canyon, Cache Co.  
 Provo, Utah Co., 4550 ft.  
 Provo Canyon, Utah Co.
- Raft River Mts., Box Elder Co.  
 Redmond, Sevier Co., 5135 ft.  
 Richfield, Sevier Co., 5310 ft.  
 Richmond, Cache Co., 4610 ft.  
 Riverdale, Weber Co.  
 River Heights, Cache Co., 4540 ft.  
 Riverton, Salt Lake Co., 4435 ft.  
 Rockville, Washington Co., 3745 ft.  
 Rocky Mouth Canyon, Salt Lake Co.  
 Roy, Weber Co.
- St. George, Washington Co., 2760 ft.  
 Salamander Lake, on Mt. Timpanogos  
 Salem, Utah Co., 4600 ft.  
 Salina, Sevier Co., 5160 ft.  
 Saltair, Great Salt Lake.  
 Salt Lake City, Salt Lake Co., 4365 ft.  
 Sandy, Salt Lake Co., 4450 ft.  
 Sardine Canyon, on Mt. Pisgah,  
 Cache Co.  
 Settlement Canyon, Tooele Co., 5100 ft.  
 Sevier River, at Hatch  
 (Alexander Stat. 2).  
 Slaterville, Weber Co.  
 Smithfield, Cache Co., 4595 ft.  
 Soldier Summit, Wasatch Co., 7440 ft.  
 South Willow Canyon, Tooele Co.  
 Spanish Fork, Utah Co., 4550 ft.  
 Springdale, Washington Co., 3915 ft.  
 Spring Hollow, in Logan Canyon.  
 Starr, Juab Co.  
 Stockmore Ranger Station,  
 Duchesne Co., 6960 ft.
- Naples, Uintah Co.  
 Narrows, see Zion National Park.  
 Nebo, Mt., Juab Co.  
 Neola, Duchesne Co.

- Stockton, Tooele Co., 5070 ft.  
 Strawberry Creek, Wasatch Co.  
 Strawberry Reservoir, Wasatch Co.,  
 7600 ft.  
 Syracuse, Weber Co., 4240 ft.
- Taylorville, Salt Lake Co., 4355 ft.  
 Ten Mile, Escalante Desert, Garfield Co.  
 Three Lakes, Kane Co.  
 Timpanogos, Mt., Utah Co.  
 Timpooneke Guard Station, American  
 Fork Canyon, Timpanogos.  
 Tony Grove Camp, in Logan Canyon.  
 Tooele, Tooele Co., 4925 ft.  
 Trenton, Cache Co., 4460 ft.  
 Trout Creek, Juab Co.  
 Tryol Lake, Uinta Mountains.  
 Tucker, Utah Co.
- Valencia, Davis Co.  
 Vernal, Uintah Co., 5520 ft.  
 Vernon, Tooele Co., 5510 ft.  
 Vineyard, Utah Co.  
 Virgin, Washington Co., 3400 ft.
- Wanship, Summit Co., 5860 ft.  
 Washington, Washington Co., 2800 ft.  
 Weeping Rock, see Zion National Park.  
 Wellsville, Cache Co., 4495 ft.  
 Whiterocks, Uintah Co., 6050 ft.  
 White Valley, Millard Co.  
 Willard, Box Elder Co., 4265 ft.  
 Willow Lake, Ferron Canyon,  
 Sanpete Co.  
 Wolf Creek Pass, Wasatch Co., 9400 ft.  
 Woodland, Summit Co.  
 Woodruff, Rich Co., 6345 ft.  
 Woodside, Emery Co., 4645 ft.
- Uintah, Weber Co. 4495 ft.  
 Upper Parrish Canyon, Farmington Mt.,  
 Davis Co., 7000 ft.
- Zion National Park, Washington Co.,  
 4500 ft. (Alexander Stat. 1).

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My deepest appreciation is extended to Mrs. Alexander, not only for invaluable aid in the collecting of specimens but very especially for much assistance in the compiling and checking of data.

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## Systematic Account

## TANYDERIDAE

*Protanyderus margarita* sp. nov.—Size small (wing, male, less than 8 mm.); general coloration of thorax light gray, the praescutum with four very poorly indicated light gray stripes; femora yellow, the tips rather narrowly infuscated; tibiae yellow, the bases and tips even more narrowly infuscated; wings whitish subhyaline, with a banded and spotted brown pattern; abdominal segments brown, the posterior borders pale yellow; male hypopygium with the dististyle deeply divided.

♂. Length, about 6.5-7.2 mm.; wing, 6-7.7 mm.

♀. Length, about 8-8.5 mm.; wing, 9-10 mm.

Rostrum and palpi black. Antennae with scape dark, gray pruinose; pedicel black, flagellum brownish black, the outer segments somewhat paler. Head gray; anterior vertex less than three times the diameter of the scape.

Pronotum brownish gray. Mesonotal praescutum light gray, with four very poorly indicated light grayish brown stripes, the intermediate pair better defined, the laterals scarcely evident in the type, a little more pronounced in a paratype; posterior sclerites of notum light gray or testaceous gray. Pleura light gray, vaguely to scarcely patterned with brighter areas. Halteres with stem whitened, knob infuscated. Legs with the coxae and trochanters pale yellow; femora yellow, the tips rather narrowly infuscated, the amount subequal on all legs; tibiae yellow, the bases and tips even more narrowly darkened; tarsi yellow, the tips of the more proximal segments narrowly infuscated, the outer two segments dark brown; penultimate segment with a conspicuous basal tooth or lobe. Wings (Fig. 1) with the ground whitish subhyaline, with a pale brown pattern, the areas very vaguely margined with darker; markings

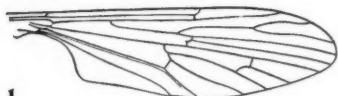


Fig. 1. *Protanyderus margarita* sp. n., venation.

1 arranged about as in *vipio*, including a postarcular spot in cells *R* and *M*, confluent with a similar area near base of Anal cell; a somewhat equal area at origin of *Rs*; a broken band at cord, narrowly interrupted at *M* and again in the Anal field; a second broken band at level of fork of  $R_{2+3}$  and outer end of cell 1st  $M_2$ ; elsewhere on wing surface with scattered spots, including marginal ones on all veins and a few other scattered areas; veins yellow, light brown in the patterned portions. Venation:  $R_{2+3}$  about one-fourth longer than  $R_2$ , the latter sinuous on distal half; cell 1st  $M_2$  about one-half longer than vein  $M_1$ .

Abdominal segments brown, the posterior borders pale yellow; subterminal segments somewhat more uniformly darker brown; hypopygium brownish yellow. Male hypopygium with the dististyle single but deeply divided, the base only about as long as the shorter arm; longer arm, at and near tip, with several long dark-colored setae.

*Holotype*, ♂, Zion National Park, altitude 4,500 ft., June 22, 1942 (*M. M. Alexander*). *Allotype*, ♀, Juliaetta, Idaho, May 3, 1901 (*J. M. Aldrich*); United States National Museum. *Paratopotype*, ♀, pinned with type; 1 additional wing, found in a spider's web at the Narrows, June 21, 1942 (*C. P. Alexander*). *Paratypes*, 1 ♂, with the allotype; 1 ♀, Gothic, Gunnison Co., Colorado, July 6, 1935 (*Inez W. Williams*), earlier recorded as *vipio*; 1 fragmentary ♂ (wings on slide), Sunset, Colorado, July 22, 1915 (*T. D. A. Cockerell*).

I named this attractive fly for Mrs. Alexander, using the second given name, Marguerite. The only other described Nearctic species of the genus are *Protanyderus vanduzeei* (Alexander, 1918) and *P. vipio* (Osten Sacken, 1877), the former of which differs conspicuously in the semi-degenerate wings, with a quite distinct pattern; the latter species still is known only from the unique type, taken along San Mateo Creek, near San Francisco, California, April 9, 1876, by Osten Sacken. It is a much larger fly (Length, male, about 10 mm.), with evident differences in the coloration of the body and legs. It should be emphasized that in the Tanyderidae the female sex is larger than the male.

#### PTYCHOPTERIDAE

*Ptychoptera lenis* Osten Sacken, 1877.—Logan Canyon, China Row Camp, June 30, 1942; Raft River, June, 1932 (*Rowe*). Needham and Christenson (1927) give a brief description of the larva and pupa, the material from Birch Glen, Logan River.

*Ptychoptera lenis coloradensis* Alexander, 1937.—Alton, May 9, 1939 (*K & Harmston*); Clarkston, April 27, 1938 (*K & Hardy*); Hyrum, April 29, 1939 (*K & Harmston*); Laketown, June 6, 1938 (*K & Harmston*).

*Ptychoptera pendula* Alexander, 1937.—Kimball's Fort, June 29, 1943 (*K*); Logan Canyon, Lodge Forest Camp, June 30, 1942; Provo, June 8, 1939 (*K & Nye*); Provo Canyon, June 29, 1939 (*K & Harmston*).

*Ptychoptera uta* Alexander, 1947.—Logan, May 1, 1941 (*Roberts*); Portage, May 1, 1939 (*K & Harmston*); Willard, April 29, 1939 (*K & Harmston*).

*Bittacomorpha clavipes* (Fabricius, 1781).—Eden, August 25, 1938 (*K & Hardy*); Garden City, August 25, 1938 (*K & Hardy*); Laketown, August 29, 1939 (*K & Harmston*); Neola, May 23, 1939 (*K & Harmston*).

#### TRICHOCERIDAE

*Diazosma subsinuata* (Alexander, 1915).—Provo Canyon, North Fork (*Hardy*).

*Trichocera garretti* Alexander, 1927.—Cottonwood Canyon, April 6, 1938 (*Nye*); Logan, March 21, 1942 (*Ashdown*); March 30, 1933 (*Thatcher*); May 1, 1939 (*K & Stains*); October 8, 1934 (*Gunnell*); Logan, Campus, March 15, 1938 (*Hardy*); April 3—20, 1938 (*K*); May 5, 1943 (*K*); Logan Canyon, June 12, 1945 (*K*); November 1, 1945 (*K*); Nibley, May 12, 1938

(Hardy); River Heights, April 7, 1943 (K); Smithfield, May 11, 1938 (K & Hardy); Spanish Fork (Hardy).

*Trichocera saltator* (Moses Harris, 1782).—Provo environs, 6,500 ft., February 21, 1936 (Hardy). This is not the species recorded as *saltator* from Wyoming (Alexander, 1945: 398). The interpretation of this fly by Edwards calls for a species with unpatterned wings and with the dististyle entirely unmodified, as in the present fly; the Teton species had a small basal lobe on the dististyle of the male, about as in *hiemalis* (DeGeer, 1776) but its strict identity must remain in question. Whether the various names currently placed in the synonymy of *saltator* actually pertain to the species seems questionable to me since the types of some of these are non-existent and strict comparisons are impossible. However, it would seem that less confusion will result if Edward's later interpretation of the synonymy is followed.

#### TIPULIDAE

##### TIPULINAE

*Holorusia* (*Holorusia*) *grandis* (Bergroth, 1888) (*rubiginosa* Loew, 1863, nec *Holorusia* (*Ctenacroscelis*) *rubiginosa* Bigot, 1863).—Maple Canyon, August 10, 1923 (Aldous); Parowan Canyon, July 20, 1919 (collector unknown); St. George (Woodbury); Spanish Fork (Horace Hardy); Trout Creek, July 29, 1939 (Stafford); Zion Canyon, June 19, 1919 (collector unknown), Weeping Rock, 4,500 ft., June 21–23, 1942.

*Prionocera uinticola* sp. nov.—Allied to *oregonica*; mesonotal praescutum gray, with three darker stripes, the median one with a narrow velvety black line on cephalic portion; tibiae and tarsi brownish black; wings brownish gray, the prearcular and costal fields more yellowed; stigma barely evident, its proximal half yellow;  $R_5$  short, only about three times *m-cu*; vein  $R_3$  upcurved, cells  $R_2$  and  $R_3$  at margin subequal in extent; abdominal tergites dark gray, with a brown central stripe, the lateral borders broadly yellow; male hypopygium with the ninth tergite terminating in six slender lobes; basistyle more or less produced into a lobe.

♂. Length, about 10.5 mm.; wing, 12.5 mm.; antenna, about 4 mm.

Frontal prolongation of head black, pruinose, the apex of sides and beneath narrowly yellow; nasus elongate; palpi black. Antennae black, the base of the first flagellar segment narrowly reddened; succeeding flagellar segments conspicuously produced on lower margin at outer end to produce a serrate appearance. Head above dark brown, including the vertical tubercle, the latter subtended by more velvety black areas; front and anterior vertex lighter gray, becoming obscured on the posterior orbits.

Pronotum dark gray, scutellum yellow. Mesonotal praescutum gray, with three darker stripes, the median one with a narrow velvety black line on cephalic portion, the stripe scarcely divided behind; posterior sclerites of notum gray, scutal lobes variegated with darker brown; parascutella yellow. Pleura chiefly gray, the dorsopleural region extensively buffy yellow; posterior pleurites and the katapleurotergite yellow. Halteres brown, knob darker brown,



vaguely paler at apex. Legs with coxae grayish pruinose; trochanters yellow; a single (fore) leg remains; femora obscure yellow, the outer fourth very gradually more infuscated; tibiae and tarsi brownish black. Wings brownish gray, the prearcular and costal fields more yellowed; stigma scarcely evident, its proximal half yellow, the outer portion very pale brown; a scarcely evident darkening in bases of outer radial cells at the anterior cord; obliterative streak extending from before stigma across base of cell 1st  $M_2$ ; veins brown, more yellowed in the costal region. Venation: Much as in *oregonica* but  $R_s$  shorter, about three times  $m-cu$ , cell  $R_1$  correspondingly widened; in *oregonica*,  $R_s$  is more nearly four times  $m-cu$ , cell  $R_1$  on basal portion very narrow; vein  $R_3$  shorter and more upcurved than in *oregonica*, cells  $R_2$  and  $R_3$  at margin subequal in extent.

Abdominal tergites dark gray, with a brown central stripe; caudal borders of segments very narrowly whitened, lateral tergal borders broadly and conspicuously yellow; sternites more uniformly brownish gray, the posterior borders very narrowly pale. Male hypopygium with the ninth tergite (Fig. 2, 9t) terminating in six slender lobes, the lateral pair elongate, clothed on outer portion with delicate setulae; sublateral lobes subequal in length, stouter at base, with coarse black setae; intermediate lobes shortest, forming the outer angle of a rectangular median plate, glabrous or virtually so. Basistyle at apex more or less produced into a lobe. Outer dististyle broadest at base, narrowed to the obtuse tip. Inner dististyle narrow, including the beak; lower beak separated from the subbasal lobe by an angular notch.

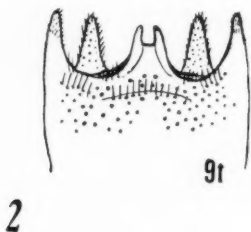


Fig. 2. *Prionocera uinticola* sp. n., male hypopygium.  
(Symbol: 9t, tergite).

*Holotype*, ♂, Tryol Lake, Uinta Mountains (John C. Fechner & Vasco M. Tanner); Alexander Collection through Hardy.

The most similar species are *Prionocera oregonica* Alexander, 1943, and *P. primoveris* Alexander, 1943, which differ especially in the details of structure of the male hypopygium. The former species is most like the present fly, differing further in the venation, as discussed.

*Nephrotoma ferruginea* (Fabricius, 1805).—Cedar City, Iron Springs, June 26, 1917, July 3, 1919 (collector unknown); Charleston, August 14, 1943 (K & Maddock); Fillmore, August 2, 1935 (Bischoff), August 7, 1939 (Bischoff); Gandy, August 8, 1945 (K); Huntsville, July 18, 1939 (K); Logan, June 11, 1943 (Maddock & Stoddard), July 19, 1939 (K & Stains); Maple Canyon, 1923 (collector unknown); Ogden, August 31, 1943 (K & Telford); Pinto, July 12, 1939 (K & Harmston); St. George, May 22, 1919



(collector unknown); Salt Lake City, June 10, 1945 (Edmunds & Mulaik), June 23, 1943 (K); Sandy, on alfalfa, September 11, 1917 (collector unknown); Spanish Fork, September 21, 1943 (K); Valencia, July 20, 1938 (K).

*Nephrotoma lugens erythrophrys* (Williston, 1893).—Alta, Little Cottonwood Canyon, July 12, 1938 (Rees), Univ. Utah 22,801; Payson Canyon (Tanner); Provo Canyon, North Fork (Hardy), BYU No. 16; Raft River Mts., 10,000 ft., June 1928 (Tanner), No. 3238; Mt. Timpanogos, Aspen Grove (Hardy), BYU No. 21.

*Nephrotoma occidentalis* (Doane, 1908).—Amalga, May 30, 1944 (K); Green River, June 14, 1945 (K); Hooper, June 13, August 3, 1937 (Hardy); Kanab, April 19, 1939 (K & Harmston); Kanesville, July 11, 1937 (K); Oak Creek Canyon, July 10, 1942 (K); Ogden, June 20, 1937 (K); Parowan, August 8, 1942 (K); Plain City, June 21, 1927 (collector unknown); Providence, June 17, 1931 (Hammond); Provo, June 5, 1944 (K); Riverdale, July 7, 1937 (K); Salem, September 25, 1943 (K); Salt Lake City, May 6, 1939 (Janes), June 15, 1933 (Stafford), September 30, 1930 (K); Smithfield, June 5, 1939 (K & Harmston); Vernon, August 5, 1930, on potatoes (K).

*Nephrotoma snowii* (Doane, 1908), var.—Leeton, July 25, 1945 (K). A single female that agrees well with the description except that praescutal stripes are black only on about their cephalic half and there are further slight differences of coloration.

*Tipula (Bellardina) commiscibilis* Doane, 1912 (*contaminata* Doane, 1901).—Box Canyon, near Maple Canyon, August 28, 1923 (Aldous); Brigham Canyon, June 17, 1938 (Hardy & Stains); Head of Fairview Canyon, September 1, 1945 (Edmunds & Mulaik); Hooper, July 6–7, 1937 (Hardy); Huntington Canyon, 6,000 ft., September 1, 1945 (Edmunds & Mulaik); Huntsville, August 25, 1938 (K & Hardy); Logan, September 21, 1935 (Rigby), at light, September 25, 1939 (K & Stains), October 10, 1936 (Harmston); Logan Canyon, August 7, 1938 (Hardy), at light, August 8, 1945 (K); Maple Canyon, August 20, 1923 (Aldous); Providence, at light, September 19, 1934 (Smith); Provo Canyon, North Fork (Hardy); Provo (Hardy), August 26–September 7, 1919 (Spalding); Salem, September 18, 1943 (K); Salt Lake City, Emigration Canyon, August 25, 1935 (Stafford); South Willow Canyon, July 4, 1942 (S. & D. Mulaik); Spanish Fork (Agnes Hardy); Wanship, August 18, 1945 (Edmunds & Mulaik).

*Tipula (Bellardina) gothicana* Alexander, 1943.—Beaver Canyon (Brooklyn Museum, collected by Charles Schaeffer, no date); the same, 7,200 ft., July 12, 1945 (K & Telford).

*Tipula (Bellardina) schizomera* Alexander, 1940.—St. George, May 26, 1919 (collector unknown), June 28, 1945 (K); Virgin, May 18, 1944 (K); Washington, June 28, 1945 (K); Zion National Park, May 13, 1936 (Rees & Duncan), Univ. Utah, 18,376. Mrs. Alexander and I found this handsome fly in various places at Zion, specifically along a small stream at the Grotto Campground, June 21, 1942, resting beneath overhanging rocks in the stream bed, and again at Weeping Rock, resting on the wet cliff faces among masses of Venushair fern.

*Tipula (Bellardina) subcinerea* Doane, 1901.—Mt. Timpanogos, Aspen Grove (Hardy, Tanner).

*Tipula (Trichotipula) macrophallus* (Dietz, 1918).—Logan Canyon, August 7, 1938 (Hardy); Provo Canyon, Deer Creek, August 19, 20, 1913 (Spalding); types.

*Tipula (Schummelia) magnifolia* sp. nov.—Allied to *subtenuicornis*: mesonotal praescutum light gray, with four brown stripes, more intense in female; antennae with scape and pedicel yellow, flagellum black; femora yellow, the tips narrowly but conspicuously blackened; wings whitish subhyaline, extensively clouded with pale brown, stigma darker brown; abdomen yellow, the tergites variegated sublaterally with dark brown; segments six to eight in male blackened to form a ring; male hypopygium with median appendage of ninth sternite entire; inner dististyle with outer basal lobe more or less bilobed; eighth sternite with the lateral lobes very large and conspicuous.

♂. Length, about 13-15 mm.; wing, 12-14 mm.; antenna, about 6-6.2 mm.

♀. Length, about 14-15 mm.; wing, 13-16 mm.

Frontal prolongation of head above obscure yellow, somewhat darker on sides; nasus short; palpi with basal two segments dark brown, the outer ones paler brown. Antennae (male) elongate; scape and pedicel yellow, flagellum black; segments with small basal enlargements; longest verticils unilaterally distributed, slightly more than one-half the length of the segments; in female, antennae shorter. Head above gray, more yellowed on front; vertical tubercle low or scarcely developed.

Pronotum grayish testaceous, vaguely patterned with darker. Mesonotal praescutum light gray, with four brown stripes that are darker colored and more intense in female; in male, intermediate stripes usually paler than the laterals; scutum gray, each lobe with two contiguous or slightly confluent dark areas; scutellum yellow, more brownish gray at base; mediotergite gray, pleurotergite more yellowed. Pleura gray, vaguely patterned with obscure yellow.

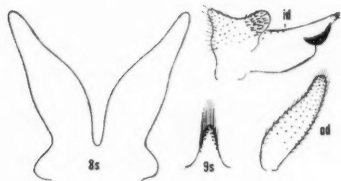


Fig. 3. *Tipula (Schummelia) magnifolia* sp. n., male hypopygium.

(Symbols: id, inner dististyle; od, outer dististyle; s, sternite; t, tergite).

3

low; dorsopleural membrane yellow. Halteres with stem and apex of knob yellow, the base of latter dark brown. Legs with the coxae yellow, sparsely pruinose; trochanters yellow; femora yellow, the tips narrowly but conspicuously black, the amount subequal on all legs; tibiae obscure yellow, the tips narrowly brownish black; tarsi black; claws (male) simple. Wings whitish subhyaline, extensively clouded with pale brown, the pattern involving most of

the cells of the wing and having the general arrangement found in the *hermannia* group; the chief white areas include the wing base, prestigmal and poststigmal markings, and an obliterative area from cell *1st M*<sub>2</sub> almost to the posterior border in cells *M*<sub>3</sub> and *M*<sub>4</sub>; stigma darker brown; cells *C* and *Sc* somewhat clearer yellow. Venation: *R*<sub>s</sub> nearly straight, subequal to the long *m-cu*; petiole of cell *M*<sub>1</sub> a little exceeding *m*.

Abdomen yellow, the first tergite darkened medially, the succeeding ones with dark brown lateral or nearly lateral markings, on the base of tergite two elongate and continuous, beyond this broken into basal and apical spots; sternites more nearly clear yellow; in male with a broad black subterminal ring involving segments six to eight, inclusive; lobes of the eighth sternite and remainder of hypopygium yellow. Male hypopygium with the median region of ninth tergite produced caudad into a small subrectangular lobe. Median appendage of ninth sternite a small simple lobe, at apex tufted with long setae, these continued down the sides of the lobe to beyond midlength. Outer dististyle pale, broadest on proximal two-thirds, the outer portion more narrowed; setae of moderate length only, lacking on basal fifth. Inner dististyle with the main body long and narrow, the beak slender, on its face with a large flat blackened lobe or flange; outer basal lobe large, more or less bilobed, the cephalic lobe with numerous spinoid setae, the vestiture of the remainder of

lobe long and delicate. Eighth sternite with the blackened base restricted in area, concealed or virtually so beneath the seventh sternite, the unusually large whitened lobes projecting caudad and dorsad, very conspicuous.

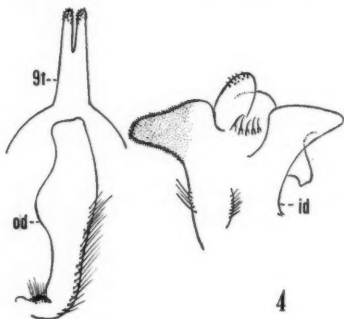


Fig. 4. *Tipula (Yamatotipula) cognata* Doane, male hypopygium. (Symbols: *id*, inner dististyle; *od*, outer dististyle; *t*, tergite).

*Holotype*, ♂, Beaver, altitude 8,000 ft., June 26, 1942 (*C. P. Alexander*). *Allotopotype*, ♀, pinned with type. *Paratopotypes*, ♂♂; *paratypes*, ♂♀, Miami, Mariposa Co., California, June 7, 1940 (*Mont A. Cazier*).

The nearest described species is *Tipula (Schummelia) subtenuicornis* Doane, 1901, which differs conspicuously in the structure of the male hypopygium, particularly of the inner dististyle and the appendages of the eighth sternite and ninth tergite.

*Tipula (Schummelia) subtenuicornis* Doane, 1901.—Logan Canyon, June 30, 1942 (*Alexander*), July 4, 1945 (*K*).

*Tipula (Yamatotipula) albocaudata* Doane, 1901.—Logan, May 26–29, 1943 (*Maddock*), June 26, 1943 (*Maddock*); Logan Canyon, May 28, 1938 (*Bischoff*), at 4800 ft., June 30, 1942 (*Alexander*).

*Tipula (Yamatotipula) cognata* Doane, 1901.—Zion National Park, May 13, 1936 (*Rees*). The present specimen agrees with a homotype that was determined by Melander, differing from *albocaudata* Doane, 1901, in certain details of structure of the male hypopygium, including the large and conspicuous outer basal lobe of the inner dististyle. Since the hypopygium has not been described and figured I am supplying these data.

Male hypopygium (Fig. 4) having the ninth tergite, 9t, produced into an elongate median lobe that is split for less than half its length, forming two slender lobules, each tipped with several blackened spiculate points. Outer dististyle, *od*, elongate, pale, truncate at tip, the lower margin beyond mid-length strongly dilated; base and posterior margin for more than the proximal half with long conspicuous black setae, on the outer half these small and inconspicuous. Inner dististyle, *id*, complex, the beak and outer basal lobe of somewhat similar shape and size, the latter densely covered with setulae; dorsal crest forming an irregularly obtuse lobe, not appearing as a spinous point as in *edmundsi* and *tephrocephala*, the outer portion with a few short but strong setae; nearer base with about five longer bristles from strong basal tubercles.

*Tipula (Yamatotipula) continentalis* Alexander, 1941.—Logan Canyon, 5,200 ft., June 30, 1942; July 26, 1939 (*Nye & Stains*); August 7, 1938 (*Hardy*); Salt Lake City, June 9, 1945 (*Harmston*); Mt. Timpanogos, Aspen Grove (*Hardy*).

*Tipula (Yamatotipula) diluta* Doane, 1901.—Amalga, May 30, 1944 (*K & Stoddard*); Benson, May 26, 1944 (*K, Bates & Stoddard*); Brigham, June 19, 1944 (*K, Wood & Stoddard*); Cache Junction, May 27, 1944 (*K*); Logan, May 7, 1941 (*Roberts*), May 26, 1944 (*K & Wood*); Logan Dry Canyon, June 23, 1944 (*Wood & Stoddard*); Mendon, August 26, 1942 (*K*); Tooele, August 4, 1938 (*K & Stains*).

*Tipula (Yamatotipula) edmundsi* sp. nov.—Allied to *albocaudata*; mesonotal praescutum gray, with three somewhat darker gray stripes that are conspicuously bordered by dark brown, the ground color of the lateral stripes almost obliterated; flagellar segments of male black, strongly incised; claws (male) small, simple; wings brownish gray, the prearcular and costal fields more brownish yellow; remainder of wing weakly patterned; *Rs* relatively short, about one-half to two-thirds longer than *m-cu*; male hypopygium with the tergal lobes elongate; outer dististyle nearly parallel-sided, obtuse at apex, the margins virtually straight; inner dististyle with the beak stout, blackened; on outer margin with a slender curved spinoid lobe, the outer basal lobe poorly developed; gonapophyses with tips subatrophied, tapering into pale membrane.

♂. Length, about 12-14 mm.; wing, 15-16 mm.; antenna, about 5.5-5 mm.

♀. Length, about 19-20 mm.; wing, 16-17 mm.

Frontal prolongation of head brownish yellow apically, including nasus, darker on sides, restrictedly pruinose at base; palpi black. Antennae with scape and pedicel light yellow; first flagellar segment obscure yellow at base, the remainder of organ black; flagellar segments of male long, strongly incised,

much more so than in *albocaudata*. Head gray, with a conspicuous brown median stripe on vertex, the sides behind eyes more brightened.

Pronotal scutum gray, variegated with brown; scutellum yellow. Mesonotal praescutum gray, with three somewhat darker gray stripes that are conspicuously bordered by dark brown, the small lateral stripes almost solidly of this color; scutum light gray, the lobes patterned with brownish gray; scutellum dark gray, the posterior portion light brown; postnotum light gray, with a more or less distinct blackish spot on either side just before midlength, the sides of the sclerite restrictedly yellow; pleurotergite brownish yellow, the katapleurotergite more pruinose on lower half. Pleura light gray, the dorso-pleural membrane light buffy. Halteres with the stem yellow, knob dark brown. Legs with the coxae light gray; trochanters yellow; femora yellow, the tips dark brown; tibiae extensively dark brown, paler basally; tarsi black; claws small, simple. Wings with a brownish gray tinge, the prearcular and costal fields more brownish yellow; stigma oval, brown; conspicuous brown

seams along *Cu* and *m-cu*; weak brown clouds at origin of *Rs* and over anterior cord; obliterative areas scarcely indicated; veins brown, more brownish yellow in the brightened fields. Venation: *Rs* relatively short, about one-half to two-thirds longer than *m-cu*; petiole of cell *M*<sub>1</sub> subequal to or shorter than *m*.

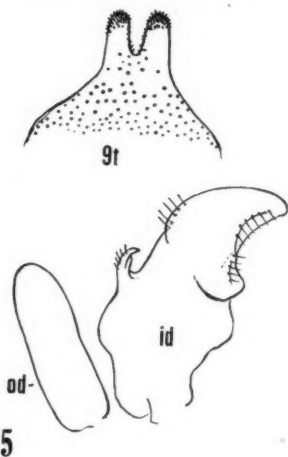


Fig. 5. *Tipula* (*Yamatotipula*) *edmundsi* sp. n., male hypopygium.

(Symbols: *id*, inner dististyle; *od*, outer dististyle; *t*, tergite).

Abdominal tergites yellow, with two broad and conspicuous dark brown longitudinal stripes, the median area extensively of the ground; outer three segments brownish black, the outer dististyles pale. Ovipositor with cerci slender and virtually straight. Male hypopygium (Fig. 5) with the ninth tergite, *9t*, having the lobes elongate, separated by a narrow U-shaped notch, in cases this deeper than in others, as shown; each lobe with abundant blackened points at apex. Outer dististyle, *od*, nearly parallel-sided, obtuse at tip, smaller than in *albocaudata*, in cases even wider than shown. Inner dististyle, *id*, with the apical portion, including beak and lower beak heavily blackened; beak stout, the lower beak more or less pendant, separated from the former by a broad rounded emargination; outer margin of crest bearing a slender curved spinous lobe; posterior portion of crest or the outer basal lobe not or scarcely developed, as in *albocaudata* and *cognata*. Gonapophyses not ter-

minating in spatulate blades, the apices subatrophied, tapering into pale membrane.

*Holotype*, ♂, Logan Canyon, May 22, 1938 (Hardy); Alexander Collection. *Allotopotype*, ♀. *Paratopotypes*, 8 ♂♂; *paratype*, ♀, Sardine Canyon, May 27, 1938 (Hardy); Fountain Green, May 10, 1939 (Knowlton & Harmston); Honeyville, April 29, 1939 (Knowlton & Bischoff); Tremonton, April 29, 1939 (Knowlton & Bischoff).

I am very pleased to name this species for Mr. George F. Edmunds, Jr., to whom I am indebted for various interesting Tipulidae. The most similar described species are *Tipula* (*Yamatotipula*) *albocaudata* Doane, 1901, and *T. (Y.) colteri* Alexander, 1943, differing especially in the structure of the male hypopygium, particularly of the dististyles. The details of coloration and the structure of the antennae are similarly distinct.

*Tipula* (*Yamatotipula*) *meridiana* Doane, 1912.—Beaver, altitude 8,000 ft., June 26, 1942; Zion National Park, 4,500 ft., June 21—22, 1942.

*Tipula* (*Yamatotipula*) *sayi* Alexander, 1911 (*costalis* Say, 1823).—Provo (Hardy); Spanish Fork, August 1, 1938 (Hardy).

*Tipula* (*Yamatotipula*) *spernax* Osten Sacken, 1877.—Coal Creek Canyon, altitude 9,000 ft., June 25, 1942; Johnson, May 9, 1939 (K & Harmston); Kanab, May 9, 1939 (K & Stains); Kanosh, September 14, 1939 (K & Harmston); Riverdale, July 7, 1937 (Hardy).

*Tipula* (*Yamatotipula*) *sulphurea jacksonensis* Alexander, 1945.—Benson, June 23, 1945 (K & Nye); Brigham, June 17, 1938 (Hardy & Stains); Cache Junction, May 27, 1944 (K); Lake Point, June 8, 1945 (K); Lewiston, May 29, 1939 (K & Bischoff); Logan, May 7, 1941 (Roberts), May 26, 1944 (K); Logan Meadows, airport, June 13, 1944 (K); Mona, June 8, 1938 (K & Harmston); Richmond, June 10, 1944 (K & Bischoff); Provo, June 5, 1944 (K & Wood); Richmond, June 10, 1944 (K, Stoddard & Wood); Spanish Fork (Hardy), August 20, 1943 (K); Starr, June 29, 1945 (K); Trenton, June 10, 1944 (K, Stoddard & Wood).

*Tipula* (*Yamatotipula*) *vicina* Dietz, 1917.—American Fork Canyon, stream margin, June 23, 1943 (K); American Fork, July 6, 1939 (K); Benson, June 23, 1945 (K & Nye); Brigham, May 27, 1938 (Hardy); Central, June 28, 1945 (K); Farmington, June 19, 1937 (Hardy); Hyrum, June 6, 1939 (Hardy); Kaysville, June 2, 1945 (K); Kimball's Fort, Silver Creek, June 29, 1943 (K & Telford); Laketown, August 21, 1942 (K, Roberts & Wood); Logan, June 13, 1944 (K & Wood), June, 1943 (K); Mona, June 8, 1938 (K & Harmston); Naples, June 28, 1943 (K); Paradise, June 14, 1938 (Hardy & Stains); Provo (Hardy, Tanner); Richfield, June 28, 1945 (K); Salt Lake City, July 2, 1939 (K); Spanish Fork, May 29—30, 1936 (Hardy).

*Tipula* (*Tipula*) *spenceriana hardyi* Alexander, 1943.—Very close to the typical form (Pacific Coast States and Provinces), differing in slight details of structure of the male hypopygium.

♂. Length, about 13—14 mm.; wing, 15—16 mm.; antenna, about 3.5—3.6 mm.

Male hypopygium with the tergite large, the caudal margin with a deep and narrow V-shaped notch; margin of lobes narrowly blackened and very

insensibly roughened but not toothed; a single denticle of moderate size on either side at end of the blackened part; furcula between them variable, from about the length of a single spine to twice this distance. Inner dististyle with beak only slightly produced, provided with simple setigerous punctures only.

*Holotype*, ♂, Eden, August 25, 1938 (G. F. Knowlton & D. Elmo Hardy). *Paratypes*, ♂♀, Allen Canyon, August 12, 1943 (Knowlton & Maddock); Clear Creek Canyon, September 4, 1933 (Rowe); Huntsville, Ogden Valley, August 21, 1942 (Knowlton, Roberts & Wood); Logan Canyon, August 25–30, September 4, 1938 (Knowlton & Nye); Mt. Nebo, August 14, 1943 (Knowlton & Maddock); Myton, September 18, 1939, at light (Zirker); Naples, September 4, 1938 (Knowlton & Harmston); Vernal, September 24, 1940 (Haws).

The subspecies is named in honor of Dr. D. Elmo Hardy, who has added most materially to our knowledge of the Tipulidae of Utah. A brief diagnosis, in conjunction with the description of *Tipula* (*Tipula*) *spenceriana* Alexander, 1943, had been given earlier (Can. Ent., 75: 142; 1943).

*Tipula* (*Tipula*) *pendulifera* Alexander, 1919.—Laketown, August 21, 1942 (K).

*Tipula* (*Arctotipula*) *illustris* Doane, 1901 (*Prionocera fuscipennis* Loew, 1865).—Brigham, June 10, 1939 (Hardy & Stains), June 24, 1944 (Wood), August 5, 1943 (K); Charleston, August 14, 1943 (K & Maddock); Collins-ton, April 26, 1939 (K & Bischoff); Corinne, June 19, 1944 (K, Stoddard & Wood); Garden City, August 21, 1942 (K, Roberts & Wood); Lakota, July 18, 1945 (K); Logan Canyon, Tony Grove Camp, July 18, 1945 (K); Ogden, June 12, 1945 (Harmston), July 10, 1937 (Hardy); Paradise, June 14, 1938 (Hardy & Stains); Peterson, June 14, 1939 (K); Uintah, June 26, 1945 (K).

In an earlier paper I had called attention to the fact that the common crane-fly that had been called *Prionocera fuscipennis* (Loew, 1865) is, in reality, not a member of the genus *Prionocera* but a *Tipula* that may be referred to the subgenus *Arctotipula*. The name is preoccupied by *Tipula fuscipennis* Curtis, 1834, and the later name *illustris* Doane, 1901, must be used for the present fly.

*Tipula* (*Vestiplex*) *leucophaea* Doane, 1901.—Uinta Mts., Tryol Lake (Fechser & Tanner).

*Tipula* (*Oreomyza*) *clathrata* Dietz, 1914.—Beaver, August 12, 1943 (K); Provo, July 30–August 1, 1912, August 14, 1913 (*Spalding*), types; Zion National Park, June 21–22, 1942, July 1, 1942 (*Degener & Peiler*).

*Tipula* (*Oreomyza*) *coloradensis* Doane, 1911.—Brighton, July 19, 1942 (S. & D. Mulaik); Garden City, June 1, 1939 (Harmston); Provo Canyon, North Fork (Hardy); Whiterocks, July 22, 1939 (K & Harmston); Wolf Creek Canyon, July 24, 1945 (K).

*Tipula* (*Oreomyza*) *gaspensis* Alexander, 1929.—Beaver, 8,000 ft., June 27, 1942; Brigham, June 17, 1938 (Hardy & Stains); Logan Canyon, 4,800 ft., June 30, 1942.

*Tipula* (*Oreomyza*) *ingrata* Dietz, 1914.—Logan Canyon, 5,200 ft., June 30, 1942; August 12, 1939 (K & Stains).

*Tipula* (*Oreomyza*) *paiuta* sp. nov.—Belongs to the *borealis* (*unca*) group; mesonotal praescutum brownish gray, with three very slightly darker



gray stripes, the median one with four brownish black lines on the cephalic portion; lateral stripes with a  $\sqcap$ -shaped border; pleura yellow, whitish pruinose, with a short dark longitudinal stripe from the propleura backward; apex of haltere whitened; femora and tibiae brownish yellow, their tips narrowly blackened; wings grayish brown, restrictedly patterned with whitish subhyaline and darker brown, the former color more restricted to the outer half of wing; abdominal tergites brownish yellow, trivittate with darker brown; male hypopygium with the tergite on either side produced laterad into a slender blackened rod or spine; outer dististyle short and stout, only about twice as long as wide, the apex broadly rounded; inner dististyle with the beak long and slender; dorsal crest produced only on outer portion, provided with some 20-25 conspicuous setae; lateral appendage entirely pale, without blackened processes; upper process an elongate-oval flattened blade; remainder of appendage consisting of a flattened subquadrate blade, the outer angle more produced than the inner one.

♂. Length, about 15 mm.; wing, 15 mm.; antenna, about 5 mm.

Frontal prolongation of head obscure yellow, slightly darker above, especially the long conspicuous nasus; sides of prolongation a little darkened; palpi with basal segments brown, the outer two segments paler. Antennae relatively long; scape and pedicel yellow; basal two or three flagellar segments with bases narrowly obscure yellow, the remainder black, including all outer segments; flagellar segments gently incised, with small basal swellings; longest verticils subequal in length to the segments. Head with the front yellow; vertex grayish yellow, with a vague darker central stripe.

Pronotum infuscated medially, paling to yellow on sides. Mesonotal praescutum with the ground brownish gray, with three very slightly darker stripes that are patterned with brownish black, the median stripe with four such lines, the intermediate dashes being shorter and broader, the others being narrow black borders to the stripes; lateral stripes with conspicuous  $\sqcap$ -shaped blackened borders; scutum with the central area yellow, each lobe with two light gray marks that are interruptedly bordered by brown; scutellum grayish buffy, with a capillary darkened median vitta; mediotergite yellowish gray, the posterior border darker and with vague pale brown spots on either side of midline. Pleura and pleurotergite yellow, sparsely whitish pruinose, the ventral sternopleurite a little darker; an abbreviated dark brown stripe extending from the propleura onto the anepisternum, not reaching the pteropleurite. Halteres with stem infuscated, darker basally, the knob deepening to black, its apex whitened. Legs with the coxae yellow, whitish pruinose, the fore pair narrowly darker at base; trochanters yellow; femora and tibiae obscure yellow or brownish yellow, the tips narrowly blackened; tarsi passing into black; claws elongate, hairy, conspicuously toothed. Wings with the ground grayish brown, restrictedly patterned with whitish subhyaline and darker brown; prearcular and costal fields more brownish yellow, cell *Sc* more yellowed; stigma darker brown; a small brown spot at origin of *Rs*; the white pattern more restricted to the outer half of wing, including extensive areas before and beyond the stigma and cord; cell *R*<sub>5</sub> chiefly pale; veins brown, more yellowed in the brightened fields. Venation: *Rs* about one-half longer than *m-cu*.



Abdominal tergites brownish yellow, with a more or less distinct darker brown median stripe and less evident sublateral ones, the posterior borders of the segments narrowly pale yellow; sternites more uniformly yellow, the posterior borders narrowly pale; subterminal segments more uniformly pale but the hypopygium chiefly dark brown. Male hypopygium (Fig. 6) with the ninth tergite, *9t*, narrowed posteriorly, on either side from the ventral surface with a slender blackened rod. Outer dististyle, *od*, short and broad, only about twice as long as wide, the tip broadly rounded. Inner dististyle, *id*, with the beak long and slender, lower beak obtuse, its lower portion with several setae; dorsal crest produced only on outer portion, with about 20–25 conspicuous setae, the more posterior ones longest; outer basal lobe conspicuous, without blackened armature. Lateral appendage entirely pale yellow, without blackened processes; upper process a flattened blade, elongate-oval in outline, the apex obtusely rounded; remainder of appendage consisting of a flattened subquadrate blade, its outer angle produced into an acute point, the inner angle more obtuse. Basistyle opposite the lateral appendage with several very long setae. Gonapophysis appearing as a flattened blade, strongly bent at base, widest about opposite midlength. Eighth sternite biemarginate; lateral lobes much shorter and more obtuse than the broad central portion; setae of mesal part of lateral lobes very dense and erect, straight, their tips acute; remaining setae of lobes dense and chiefly longer and more delicate.

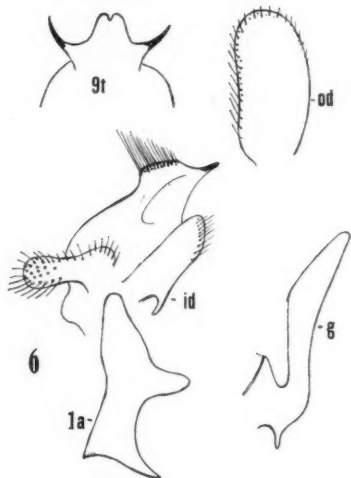


Fig. 6. *Tipula (Oreomyza) paiuta* sp. n., male hypopygium.

(Symbols: *g*, gonapophysis; *id*, inner dististyle; *la*, lateral appendage; *od*, outer dististyle; *t*, tergite).

*Holotype*, ♂, Kanosh, Millard Co., June 27, 1945 (G. F. Knowlton).

The only approximately similar species is *Tipula (Oreomyza) doanei* Dietz, 1914, which has certain of the details of the male hypopygium about the same. This latter differs in the coloration and in the structure of both dististyles, including the lateral appendage, and in the gonapophyses. The entirely pale yellow lateral appendage readily separates the present fly from the other regional members of the group, all others having at least some of the processes heavily blackened.

*Tipula (Oreomyza) rohweri* Doane, 1911.—Fort Duchesne, July 25,

1945 (K); Logan, August 1, 1939 (K); Logan Canyon, 5,200 ft., June 30, 1942; Oakley, August 15, 1943 (K & Maddock); Strawberry Reservoir, July 25, 1945 (K); Wolf Creek Canyon, July 24, 1945 (K).

*Tipula (Oreomyza) yellowstonensis* Alexander, 1946.—Spanish Fork (Hardy); part of type material.

*Tipula (Oreomyza) perexigua* Alexander, 1924.—Logan Canyon, July 16, 1945 (K).

*Tipula (Lunatipula) accurata* Alexander, 1927 (*johannus* Alexander, 1945).—Mt. Nebo, August 14, 1943 (K & Maddock).

*Tipula (Lunatipula) acuta* Doane, 1901.—Rockville, May 5, 1943 (K); Zion National Park, May 5, 1943 (K); "present by the thousands one-fourth mile below Zion Lodge"—G. F. Knowlton.

*Tipula (Lunatipula) barbata* Doane, 1901.—Huntington Canyon, 6,000 ft., September 1, 1945 (Edmunds & Mulaik); Logan, September 10, 1943 (K), September 23, 1943 (K & Maddock); Orangeville, near summit of mountains to the west, 10,000 ft., September 6, 1945 (K); Provo Canyon, North Fork (Hardy); Spanish Fork, August 20, 1943 (Hardy & K); Mt. Timpanogos, Glacier Lake (Hardy).

*Tipula (Lunatipula) bisetosa* Doane, 1901.—Appledale, July 21, 1939 (K); Charleston, August 14, 1943 (K); Butterfield Canyon, July 11, 1942 (S. & D. Mulaik); Logan Canyon, July 28, 1938 (Hardy & Stains), August 7, 1938 (Hardy); Magna, August 1, 1942 (K); Mantua, August 1, 1942 (K); Mt. Nebo, August 14, 1943 (K & Maddock); Oak Creek Canyon, July 10, 1942 (K); Mt. Timpanogos, Aspen Grove (Hardy).

The details of the male hypopygium are shown in Fig. 7. Particular attention is called to the structure of the phallosome, *p*, especially the curved median rod that is quite evident even in dried specimens and is diagnostic for the species.

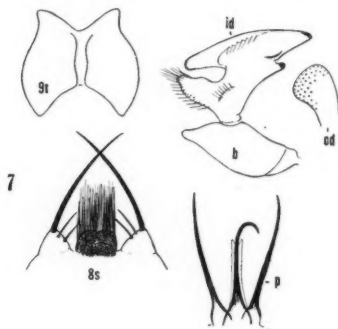
*Tipula (Lunatipula) flavocauda* Doane, 1912 (*buenoi*, Alexander, 1946).—St. George, April 23, 1942 (K), May 6, 1943 (K). Very similar to the types of *buenoi* from Arizona and New Mexico but with the tergal spines of the male hypopygium smaller.

*Tipula (Lunatipula) diversa* Dietz, 1921.—Beaver Canyon, 7,000 ft., July 12, 1945 (K & Telford); Logan, campus, June 6, 1944 (Stoddard); Logan Canyon, August 8, 1945 (K); Salt Lake City, May 16, 1940 (Tom Smart); Spanish Fork, May 19—June 10, 1946 (Hardy); Vineyard, June 1912 (Spalding), types; Zion National Park, 4,500 ft., June 21—22, 1942.

*Tipula (Lunatipula) dorsimacula* Walker, 1848 (*angustipennis* Loew, 1863).—Amalga, May 6, 1944 (Maddock), May 30 1944 (K & Stoddard); Castle Valley, April 13, 1934 (Gaufin & Telford); Clarkston, April 27, 1938 (K & Hardy); Hooper, July 7, 1937 (Hardy); Logan, March 21, 1942 (D. Ashdown), April 18, 1931, April 20, 1934, April 26, 1936 (Harmston), April 28, 1930, May 1, 1932 (J. H. Linford), May 1, 1937 (W. A. Frahm), May 3—17, 1938 (W. A. Frahm) May 7, 1932, May 9, 1939 (Bischoff), June 1, 1931, June 14, 1943 (Maddock); Ogden, April 24, 1943 (K & Maddock); Providence, April 26, 1934 (C. F. Smith), May 1, 1931 (R. J. James);

Provo, (Hardy, Fechsner, Tanner), April 1926 (C. Lynn Hayward); Provo Canyon, North Fork (Hardy), B.Y.U. 30; Salt Lake City, May 19, 1929, on lawn (W. Ivie), May 31, 1920 (A. M. Woodbury); Spanish Fork (Hardy), B.Y.U. 31; Taylorsville, April 2, 1918, April 20, 1940 (van den Akter).

As will be noted from the above, this conspicuous fly is one of the earliest of the larger species of *Tipula* to appear and is often collected by college students. The heavy-bodied female is rarely capable of sustained flight and is more frequently found crawling and fluttering over the ground.



*Tipula (Lunatipula) lamellata* Doane, 1901 (*rangiferina* Alexander, 1915).—Logan, August 6, 1942 (K & Roberts), July 16, 1945 (K); Logan Canyon, July 14, 1938 (Hardy & Stains).

Fig. 7. *Tipula (Lunatipula) bisetosa* Doane, male hypopygium.

(Symbols: b, basistyle; id, inner dististyle; od, outer dististyle; p, phallosome; s, sternite; t, tergite).

*Tipula (Lunatipula) lyrifera* Dietz, 1921.—Beaver Canyon, 7,200 ft., July 12, 1945 (K & Telford); Fillmore, among June grass, May 31, 1945 (K); Maple Canyon, June 12, 1943 (K & Telford); Mill Creek Canyon, June 24, 1938 (K & Hardy); Provo Canyon, North Fork (Hardy), B.Y.U. 32, 35; South Willow Canyon, July 4, 1942 (Mulaik); Vineyard, June 6, 1912 (Spalding), type.

*Tipula (Lunatipula) macrolabis macrolaboides* Alexander, 1918.—Mt. Timpanogos, July 26, 1942 (K).

*Tipula (Lunatipula) madina* Dietz, 1921.—Provo, June 24, 1912 (Spalding), type.

*Tipula (Lunatipula) mormon* sp. nov.—Belongs to the *unicincta* group, allied to *bigeminata*; general coloration of thorax opaque yellow, the praescutum with three scarcely differentiated yellow stripes; femora yellow, the tips narrowly infuscated; wings with a weak brownish tinge, the cells of the basal half paler; a very conspicuous white mark across base of cell 1st  $M_2$ ; male hypopygium relatively large; ninth tergite transverse, the caudal margin with a small median notch, the broad lateral lobes produced caudad into a narrow blackened point; ventral surface of tergite on either side with a blackened spine that is directed mesad; inner dististyle with beak slender, lower beak stout, transversely corrugated; dorsal crest low, glabrous; outer basal lobe densely clothed with long delicate setae, the pale apical portion with fewer coarse setae; phallosome symmetrical, consisting of two powerful reddened spines and two short straight blades; lateral lobes of eighth sternite terminating in a single very powerful fasciculate bristle.

♂. Length, about 16 mm.; wing, 16.5 mm.; antenna, about 4 mm.

Frontal prolongation of head yellow, slightly more reddish yellow on the ventral half; nasus small; palpi with basal two segments obscure yellow, outer segments dark brown. Antennae with scape and pedicel clear light yellow; first flagellar segment a trifle more darkened; remaining flagellar segments dark brown; flagellar segments with basal enlargements relatively large, longest verticils subequal in length to the segments. Head light grayish yellow; vertical tubercle low and inconspicuous.

Pronotum yellow, with a more obscure yellow pollen. Mesonotum opaque, yellow, the praescutum with three scarcely differentiated yellow stripes that are not pollinose; posterior sclerites of the notum, especially the postnotum, with a more whitish yellow bloom. Pleura brownish yellow, with a more whitish bloom; dorsopleural region light yellow. Halteres yellow, the base of knob infuscated. Legs with the coxae yellow, whitish pollinose; trochanters yellow; femora and tibiae yellow, the tips narrowly infuscated; tarsi passing into dark brown; claws toothed. Wings with a weak brownish tinge, the cells of the basal half paler; prearcular and costal regions, with vein *Cu* and its vicinity, more brownish yellow; stigma pale brown; scarcely evident whitish areas before and beyond the stigma; a very conspicuous white mark from the outer end of cell *R*, across cell 1st *M*<sub>2</sub> into the base of *M*<sub>3</sub>; veins light brown. Venation: *Rs* about one-third longer than *m-cu*; petiole of cell *M*<sub>1</sub> and *m* subequal.

Abdomen with basal segments chiefly yellow, the outer segments, including hypopygium, more infuscated. Male hypopygium (Fig. 8) relatively large and conspicuous. Ninth tergite, 9<sub>t</sub>, transverse, the caudal margin with a small and narrow median notch; lateral lobes broad, each produced caudad into a slender blackened spine or point; on dorsal surface with a deep median furrow; on ventral face on either side with a blackened spine that is directed toward the midline. Ninth sternite, 9<sub>s</sub>, with the appendage narrowed and obtuse at tip, the apex and outer margin with very abundant retrorse reddened bristles. Basistyle complete, the outer margin strongly sinuous but not produced. Outer dististyle, *od*, pale, about four times as long as wide; setae of basal half restricted to outer margin, pale in color; on apical third the setae longer, dark-colored, conspicuous. Inner dististyle, *id*, with the beak slender, lower beak much stouter, its lower surface coarsely corrugated; dorsal crest low, glabrous, the surface of style along base of crest with long yellow setae that are directed backward, these becoming more abundant behind; posterior crest small and pale, glabrous; outer basal lobe relatively small but very conspicuous by the abundant long pale setae that are distributed in more or less distinct transverse rows, producing a weakly banded appearance; apex of lobe further extended into a pale lobule with sparse coarser setae; sensory area placed at base of the outer basal lobe. Phallosome symmetrical, consisting of two powerful reddened spines that jut from the genital chamber, and two shorter straight slender blades. Eighth sternite with the upper median plate at posterior border of the following sternite having its outer edge broadly emarginate, the lateral lobes thus conspicuous; lateral lobes of sternite ter-

minating in a powerful reddened fasciculate pencil or mat of bristles; median region of sternite with a semidetached pad covered with long reddish setae.

*Holotype*, ♂, Spanish Fork, June 10, 1936 (*D. Elmo Hardy*); Alexander Collection.

When compared with *Tipula* (*Lunatipula*) *inadusta* Alexander, 1946, and other somewhat similar yellow species of the *unicincta* group, the present fly is readily distinguished by the structure of the male hypopygium, particularly the very different ninth tergite.

*Tipula* (*Lunatipula*) *pellucida* Doane, 1912 (*clara* Doane, 1901).—Benson, June 3, 1936 (collector unknown); Eden, June 2, 1938 (*K & Stains*); Farr West, May 9, 1938 (*K & Hardy*); Honeyville, May 27, 1938 (*Hardy*); Hooper, August 8, 1937 (collector unknown); Kanab Canyon, May 5, 1943 (*K*); Logan, May 26, 1944 (*K*); Logan Canyon, May 8, 1938 (*Hardy*), June 30, 1942; Logan Dry Canyon, May 9, 1938 (*Stains*); Providence Canyon, June 7, 1933 (collector unknown); Raft River Mts., 10,000 ft., June 1936 (*Tanner*); Riverton, May 9 1938 (*K & Hardy*); Salt Lake, May 21, 1928 (*A. M. Woodbury*, *G. C. Hyde*); Salt Lake City, August 21, 1928 (*Woodbury*); Salt Lake City, Dry Canyon, May 4, 1940 (*K. Wilson*); Sardine Canyon, May 31, 1938 (*Hardy*); Slate Canyon, May 14, 1919 (*Spalding*); Smithfield, May 11, 1938 (*K & Hardy*); Spanish Fork, May 19, 1936 (*Hardy*).

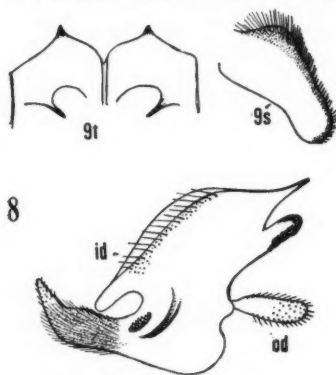


Fig. 8. *Tipula* (*Lunatipula*) *mormon* sp. n., male hypopygium.

(Symbols: *id*, inner dististyle; *od*, outer dististyle; *s*, sternite; *t*, tergite).

*Tipula* (*Lunatipula*) *pyramis* Doane, 1912.—The following records are based on determinations made by the late Dr. William G. Dietz. I am not certain of the identity of the species, based on my own knowledge. Eureka, June; Provo, June; Provo Canyon, Deer Creek, August; Stockton, June; Vineyard, July, August (all collected by Spalding).

*Tipula* (*Lunatipula*) *rabiosa* Alexander, 1943.—Monte Cristo, July 24, 1943 (*K*); Parrish Canyon, near head, July 23, 1942 (*K*).

*Tipula* (*Lunatipula*) *sanctae-ritae* Alexander, 1946, var.—Washington, May 18, 1944 (*K*); Zion National Park, 4,500 ft., June 21, 1942. Very similar to the type (Arizona) but differing in slight details of the male hypopygium, particularly of the ninth tergite. Most of the specimens are much larger than the unique type specimen.

*Tipula (Lunatipula) sinistra* Dietz, 1921.—Beaver, in the mountains, July 10, 1942 (K).

*Tipula (Lunatipula) spaldingi* Dietz, 1921.—Bluff, April 28, 1935 (B. E. & H. D. Rees); Eureka, June 30, August 1, 1911 (collector unknown); Provo, June 24, 1912 (collector unknown); Stockton, June 13, 1913 (*Spalding*), types; Zion National Park (*Rees*).

The most closely allied species is *Tipula (Lunatipula) albocincta* Doane, 1901, which was inadvertently omitted from Dietz's key to the species of the *impudica* group (Ann. Ent. Soc. America, 14: 3-4; 1921). The male hypopygium of *spaldingi* has not been adequately figured (Fig. 9). Ninth tergite, 9t, narrowly transverse; median lobe (subtergal process) elongate, compressed-flattened, ending in pale membrane; canthi unusually long and narrow, acute, the median notch very narrow; lateral processes appearing as slightly wider flattened blades that are directed chiefly caudad. Basistyle with its lower margin produced into a flattened cultrate blade, the point acute. Outer dististyle, od, unusually narrow, a trifle broader across the base. Inner dististyle, id, with the beak broadly obtuse, blackened; posterior crest small, pale; outer basal lobe more or less oval in outline, the apex obtuse. Gonapophyses, g, conspicuously developed, somewhat as in *albocincta*, but of different shape, each very unequally bifid, the axial spine long and powerful, the lateral spine very small, both acute. Eighth sternite, 8s, with the caudal margin truncate, with

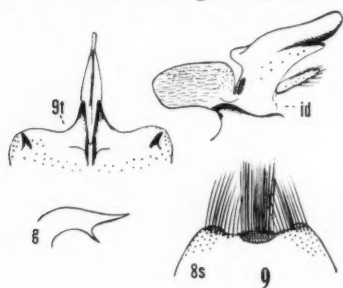


Fig. 9. *Tipula (Lunatipula) spaldingi* Dietz, male hypopygium.

(Symbols: g, gonapophysis; id, inner dististyle; s, sternite; t, tergite).

*Tipula (Lunatipula) splendens* Doane, 1901.—Blacksmith Fork Canyon, June 12, 1938 (*Hardy*); Brigham, June 17, 1938 (*Hardy & Stains*); Castilla, July 8, 1945 (*Edmunds & Mulaik*); Devils Slide, June 26, 1945 (K); Fish Lake, June, 1930 (*Rowe*); Holden, July 21, 1943 (K); Logan, July 13, 1943 (K); Logan Canyon, August 8, 1945 (K); Marriott, June 30, 1945 (K); Mill Creek Canyon, June 24, 1938 (K & *Hardy*); Monte Cristo, July 18, 1939 (K); Salt Lake City, City Creek Canyon, June 30, 1945 (K); Mt. Timpanogos, July 26, 1942 (K).

*Tipula (Lunatipula) tanneri* sp. nov.—Belongs to the *unicincta* group, allied to *inadusta*; general coloration of thorax gray, the praescutum with four more reddish brown stripes; head with a capillary dark brown median vitta; femora yellow, the tips narrowly brownish black; wings with a brownish tinge, restrictedly patterned with brown and with a conspicuous obliterative area at

cord; male hypopygium with the tergal lobes elongate, nearly parallel, their tips oblique; appendage of ninth sternite cylindrical, with a single pair of strong reddish setae at apex; phallosome symmetrical, with a single pair of strong reddish spines; lateral lobe of eighth sternite terminating in a single unusually fasciculate bristle.

♂. Length, about 16-18 mm.; wing, 17-19 mm.; antenna, about 4.9-5 mm.

♀. Length, about 18 mm.; wing, 19 mm.

Frontal prolongation of head yellow, slightly pruinose above, especially basally, sides of prolongation infuscated; nasus short; basal three segments of palpi brownish yellow, the terminal one passing into dark brown. Antennae with scape and pedicel yellow, basal flagellar segments bicolored, brown on the small basal swelling, the remainder yellow; on about the sixth segment the bicolored nature is lost and the color is uniformly dark brown; longest verticils exceeding the segments. Head above light gray, with a capillary dark brown median vitta, with less distinct dark areas on either side.

Pronotum gray. Mesonotal praescutum gray with four more reddish brown stripes, the intermediate pair narrower and more or less interrupted at near midlength; posterior sclerites of notum light gray, the scutal lobes patterned with reddish brown. Pleura light gray, vaguely patterned with slightly darker gray; dorsopleural membrane light yellow. Halteres brownish yellow, the stem restrictedly yellow at base, the knob dark brown. Legs with the coxae light gray; trochanters yellow; femora yellow, the tips narrowly but conspicuously brownish black; tibiae yellow, the tips more narrowly blackened; tarsi obscure brownish yellow, passing into black; claws (male) toothed. Wings with a brownish tinge, the prearcular and costal fields more yellowed; stigma small, darker brown; poorly indicated dark spots at arculus, end of *Sc*, along cord and on adjoining portion of vein *Cu*; oblitative area at cord conspicuous, extending from costa almost across the wing along vein *M*<sub>4</sub>, more expanded and whitened over cell 1st *M*<sub>2</sub>; two small whitish areas in outer end of cell 1st *A*, including one at end of vein 1st *A*; no poststigmatal brightening; veins pale brown, more yellowed in the brightened portions. Venation: *Rs* a little less than twice *m-cu*; petiole of cell *M*<sub>1</sub> subequal to or shorter than *m*.

Basal abdominal tergites yellow; on posterior ring of tergite two and succeeding segments with an oblique sublateral area, these becoming more extensive and conspicuous on outer segments; lateral borders broadly yellow, the caudal margins more narrowly so; sternites chiefly yellow, the outer segments, including hypopygium, dark reddish brown. Male hypopygium (Fig. 10) with the lobes of the tergite, 9*t*, elongate and nearly parallel, about as in *bigeminata*, the tips obliquely truncated and more or less thickened; a broad dorsal furrow that is not fringed with setae. Appendage of ninth sternite, 9*s*, narrowed into a cylindrical lobe that is provided with abundant strong reddish setae that are concentrated on about the outer third, at the tip grouped into a pencil; fewer and longer normal setae along the margin of the appendage. Outer dististyle, *od*, dilated at apex. Inner dististyle, *id*, with the beak slender, the lower beak stouter and heavily blackened; dorsal and posterior crests large and conspicuous, their margins microscopically ser-



ulate; outer basal lobe relatively large, bearing a small glabrous lobule on posterior margin near base. Phallosome, *p*, symmetrical, consisting of two powerful reddish spines, nearly straight, gradually narrowed to the acute tips; an inner shorter pair of blades. Eighth sternite, *8s*, with the lateral lobe short and stout, with a very powerful bristle that is unusually flattened and fasciculate; three or four other smaller bristles down the face, mesal border of lobe with dense brushes of setae that are strongly bent and recurved at near midlength; a low median lobe that bears about a dozen very modified frond-like setae, flattened and fimbriate at their outer ends (one shown enlarged); lying more basad, a transverse and feebly bilobed cushion that is densely provided with long reddish setae that split at their tips into fine filaments.

*Holotype*, ♂, Zion National Park, 4,500 ft., June 21, 1942 (C. P. Alexander). *Allotype*, ♀, Gothic, Colorado, 9,500 ft., July 4, 1934 (C. P. Alexander). *Paratopotypes*, 2 ♂♂, with the types; *paratypes*, 4 ♂♂, with the allotype, 9,500-10,000 ft., July 4-9, 1934 (C. P. Alexander); 1 ♂, Kebler Pass, Gunnison Co., Colorado, 10,150 ft., July 15, 1934 (C. P. Alexander).

The Colorado material had earlier (Amer. Midl. Nat., 29: 153-154; 1943) been recorded as *Tipula (Lunatipula) bigeminata* Alexander, 1915, but a dissection of the male hypopygium of the holotype of the latter, kindly made by Dr. Alan Stone, shows that it is, in reality, a very different species, having the phallosome asymmetrical, with a median element of characteristic shape. I take pleasure in naming this fly for Professor Vasco M. Tanner, of Brigham Young University. The species is closest to *Tipula (Lunatipula) inadusta*

Alexander, 1946, and *T. (L.) ruidoso* Alexander, 1946, among those species that have the phallosome symmetrical or without an unpaired median element. From these and others it is distinguished by the details of structures of the male hypopygium.

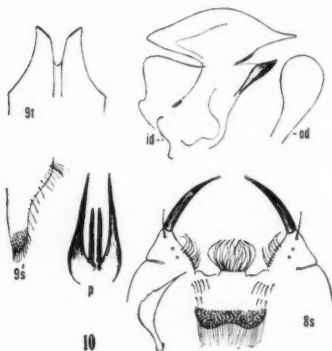


Fig. 10. *Tipula (Lunatipula) tanneri* sp. n., male hypopygium.

(Symbols: *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *s*, sternite; *t*, tergite).

*Tipula (Lunatipula) utahicola* sp. nov. — Belongs to the *impudica* group; size small (wing, male, 13 mm.); general coloration gray, the praescutum with four conspicuous dark brown stripes; antennae with scape and pedicel yellow, flagellum black; femora obscure yellow, the tips brownish black; wings whitish subhyaline, patterned with brownish gray and brown, most intense and conspicuous in cells  $R_2$  and  $R_3$ , appearing as paler streaks in other cells, as 1st  $A$ ; abdominal tergites obscure yellow, with three narrow broken brown stripes; male hypopygium with the median lobe of tergite depressed, canthi obtuse; inner dististyle with the outer basal lobe of moderate

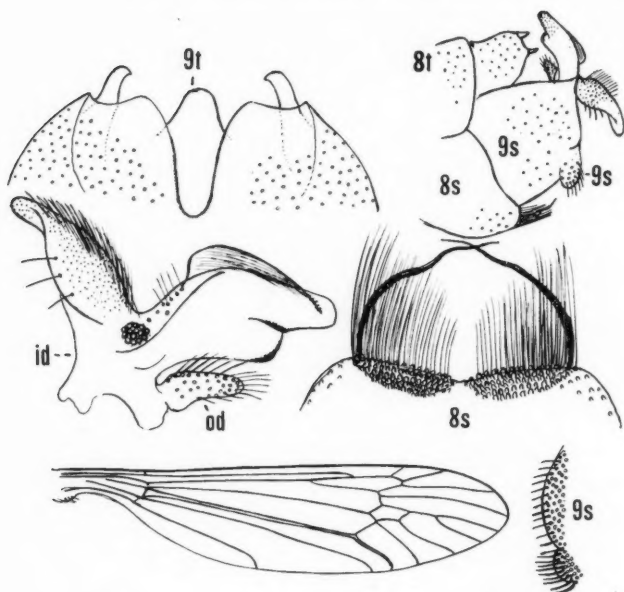
size only; eighth sternite broad at apex, with numerous setae, including a strong modified one on either side, decussate across the midline.

♂. Length, about 12 mm.; wing, 13 mm.; antenna, about 1.4 mm.

Frontal prolongation of head brown, pruinose; nasus elongate; basal segments obscure yellow, the outer ones black. Antennae with scape and pedicel yellow, the latter paler; flagellum black, the segments moderately incised; longest verticils a little shorter than the segments. Head brownish gray, with a delicate blackish median line, the sides of the posterior vertex more brightened.

Pronotum gray, patterned with brown; scutellum light yellow, strongly emarginate medially. Mesonotal praescutum gray, with four narrow but conspicuous dark brown stripes, the relatively broad space between the intermediate pair darker gray; setae of interspaces relatively abundant, from small black punctures; scutum brownish gray, each lobe with two brown areas; posterior sclerites of notum pale brown, sparsely pruinose, more or less darkened medially. Pleura pale brown, pruinose; dorsopleural membrane yellow. Legs with the coxae light gray, paling to yellow apically; trochanters yellow; femora obscure yellow, the tips rather narrowly but conspicuously brownish black, the amount subequal on all legs; tibiae brownish yellow, the tips very narrowly infuscated; tarsi blackened, the basitarsi obscure yellow on proximal portions; claws simple. Wings (Fig. 11) whitish subhyaline, patterned with pale brownish gray and brown, most intense in cells  $R_2$  and  $R_3$ ; the paler washes occur over the anterior cord, in outer medial cells, outer end of cell  $M$ , outer end of cell  $Cu$  adjoining the vein, and as a conspicuous central streak in cell  $1st\ A$ ; stigma relatively small, darker brown; the white ground includes virtually the basal third of wing, the conspicuous oblitative area at and before cord, a more restricted poststigmatal brightening, most of cell  $R_5$  to the wing-tip, and less evident areas elsewhere; prearcular field and wing base restrictedly more yellowed; veins dark brown, much paler in the brightened costal and prearcular fields. Venation: Cell  $1st\ M_2$  variable in shape and size in the two wings of the unique type,  $m$  being subequal to or shorter than the petiole of cell  $M_1$ .

Abdominal tergites obscure yellow, the first more pruinose basally; segments narrowly trivittate with brown, more evidently so on the proximal segments, the stripes narrow and broken on the intermediate and outer segments, particularly the median vitta; lateral tergal borders more grayish pruinose; basal sternites more infuscated, the outer ones passing into yellow; subterminal segments, including the eighth sternite, chiefly darkened; remainder of hypopygium largely yellow. Male hypopygium (Fig. 11) with the ninth tergite,  $9t$ , having the median lobe (subtergal process) broadly depressed, its tip obtusely rounded; canthi obtuse to subangulate; on ventral surface of each lobe the lateral process juts caudad as a narrow flattened rod, its tip obtuse. Basistyle,  $b$ , broad, its upper outer angle produced into a short but evident spinous point. Outer dististyle,  $od$ , small, subtriangular, narrowed outwardly, clothed with long conspicuous setae. Inner dististyle,  $id$ , with the beak obtuse, blackened; subapical beak shorter and stouter, more nearly truncated at apex; crest low but becoming more conspicuous on its



## 11

Fig. 11. *Tipula (Lunatipula) utahicola* sp. n., male hypopygium and venation.  
(Symbols: id, inner dististyle; od, outer dististyle; s, sternite; t, tergite).

posterior portion; sensory area consisting of about a dozen pores; outer basal lobe shorter than the main body of style; flattened, twisted, on basal portion near the sensory area with unusually abundant and conspicuous setae, these becoming more sparse outwardly. Ninth sternite with the appendage low, conspicuously setiferous; its most ventral portion slightly more produced and with a compact grouping of short stout setae. Eighth sternite relatively short, its apex very broad, with a conspicuous cushion or fringe of setae, this microscopically broken or interrupted at the midline; a single, unusually long flattened bristle at extreme outer lateral angle; sublateral setae longer and more dense than the inner ones, all evidently crinkly.

*Holotype*, ♂, White Valley, Millard Co., May 1, 1940; received from Miss Jane C. Dirks; Collector's No. 53.

The nearest relative of the present fly appears to be *Tipula (Lunatipula) mitrata* Dietz, 1921, of New Mexico, which is similarly a small fly with the details of structure of the male hypopygium different, involving the tergite, inner dististyle and eighth sternite.

*Tipula (Lunatipula) woodi* sp. nov.—Belongs to the *impudica* group; size medium (wing, male, about 17 mm.); mesonotum gray, the praescutum

with three more reddish brown stripes, the broad central one narrowly bordered with darker brown on its anterior portion; femora and tibiae yellow, undarkened; wings brownish yellow, the prearcular and costal fields conspicuously light yellow; oblitative areas very restricted and inconspicuous; male hypopygium with the median lobe of tergite compressed flattened, canthi obtuse, lateral processes very broad, the apex truncated and heavily sclerotized; inner dististyle with the outer basal lobe long and narrow, about two-thirds as long as the style itself, the tip obtuse.

♂. Length, about 18 mm.; wing 17.5 mm.; antenna, about 4.5 mm.

Frontal prolongation of head uniformly yellow; nasus virtually lacking, reduced to a low tubercle; basal two segments of palpi obscure yellow, the remainder dark brown. Antennae with basal three segments yellow, remaining segments dark brown, the small but distinct basal swellings slightly darker; longest verticils shorter than the segments. Head light brown, more pruinose anteriorly, the orbits light gray; a capillary brown median vitta; vertical tubercle low, entire.

Pronotum obscure yellow, vaguely patterned with pale brown. Mesonotal praescutum gray with three more reddish brown stripes, the median one more distinct, on about its cephalic half narrowly bordered by darker brown, on the posterior border similarly margined with yellow; lateral stripes very indistinct; posterior sclerites of notum light gray, the scutal lobes variegated with reddish brown; a vague central line of the same color on the scutellum and mediotergite. Pleura pale yellow, very sparsely pruinose, the ventral sternopleurite slightly darker; dorsopleural membrane pale yellow. Halteres yellow, the knobs weakly darkened. Legs with the coxae yellow, sparsely pruinose, the anterior faces with conspicuous setae; femora and tibiae yellow; tarsi passing into black; claws (male) toothed. Wings with a strong brownish yellow tinge, the prearcular and costal fields more saturated yellow; stigma very pale brown;

oblitative area before cord very restricted and inconspicuous, scarcely entering the cell  $M_3$ ; no dark seam on  $Cu$ ; veins pale brown, more brownish yellow in the brightened fields. Venation:  $R_s$  about one-third longer than  $m-cu$ ;  $R_{1+2}$  preserved;  $m$  sinuous, longer than petiole of cell  $M_1$ .

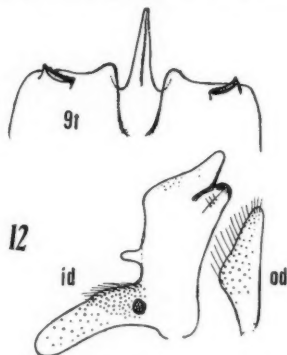


Fig. 12. *Tipula (Lunaticipula) woodi* sp. n., male hypopygium.

(Symbols: id, inner dististyle; od, outer dististyle; t, tergite).

Abdomen yellow, the tergites with three broken brownish black stripes; hypopygium chiefly yellow. Male hypopygium (Fig. 12) having the ninth tergite,  $9t$ , with the median lobe (subtergal process) compressed-flattened; canthi

obtuse, their margins microscopically crenulate; lateral process very broad, the apex truncated and heavily sclerotized, microscopically toothed. Outer dististyle, *od*, broadest at near midlength, thence narrowed to the obtuse tip. Inner dististyle, *id*, with both beak and lower beak obtuse; posterior crest unusually small, pale; outer basal lobe long and narrow, about two-thirds as long as the main body of style, apex obtuse; sensory area compact, comprised of more than 15 pores. Phallosome without conspicuous spinous armature, as in *albobincta*, *spaldingi* and others. Eighth sternite with a relatively sparse median fringe of long setae; at base with a very small fleshy median lobe, this less than twice as long as wide across base, entirely pale, the apex obtuse.

*Holotype*, ♂, Spanish Fork, altitude 4,550 ft., June 10, 1936 (*D. Elmo Hardy*); Alexander Collection, through Knowlton.

The present fly is named for Mr. Stephen L. Wood, who has aided Professor Knowlton in the capture of many interesting Tipulidae from Utah. The species is most nearly allied to *Tipula* (*Lunatipula*) *impudica* Doane, 1901, and *T. (L.) spernata* Dietz, 1921, yet is entirely distinct. The unusually broad and sclerotized lateral processes of the ninth tergite of the hypopygium are noteworthy.

#### LIMONIINAE

##### LIMONIINI

*Limonia* (*Metalimnobia*) *cinctipes* (Say, 1823).—Monte Cristo, toward Allen Camp, 7,000 ft., August 21, 1942 (*K & Maddock*).

*Limonia* (*Limonia*) *indigena jacksoni* (Alexander, 1917).—Spanish Fork, June 8-14, 1936 (*Hardy*).

*Limonia* (*Limonia*) *sciophila* (Osten Sacken, 1877).—Allen Canyon, below Monte Cristo, July 24, 1943 (*K & Maddock*); Logan Canyon, June 17, 1938 (*Hardy*).

*Limonia* (*Limonia*) *simulans concinna* (Williston, 1893).—Hooper, July 27-August 8, 1937 (*K*); Little Salt Lake, July 19, 1919 (collector unknown); Logan, July 17, 1938 (*D. E. & A. T. Hardy*); Logan Camp, July 21, 1937, October 3, 1937 (*Hardy*); Logan Canyon, October 14, 1945 (*K*), October 26, 1945 (*Ted & Mary Tibbetts*); Provo, August 1, 1937 (*Hansen*); River Heights, May 2, 1944 (*Wood*); South Willow Canyon, July 4, 1942 (*Mulalik*); Mt. Timpanogos, Glacier Lake (*Hardy*).

*Limonia* (*Limonia*) *venusta* (Bergroth, 1888) (*negligens* Alexander 1927).—Garden City, July 24, 1943, seepage along shore of Bear Lake (*K & Maddock*); Indian Canyon, April 23, 1943 (*K & Wood*); Logan, April 13, 1938 (*Hardy*), April 20, 1938 (*K & Hardy*), April 26, 1943 (*K*), June 9, 1943 (*Maddock*), August 20, 1942 (*K*), August 21, 1939 (*K*), August 25, 1943 (*K*), September 6, 1938, at light (*K. & Nye*), September 13-23, 1943 (*K*), October 5, 1943 (*K*); North Logan, September 20, 1943 (*K*); Logan Canyon, July 4, October 14, 1945 (*K*); Salt Lake City, September 21, 1939 (*Rees*); Spanish Fork, September 12, 1943 (*K*); Trout Creek, July 27, 1933 (*Stafford*); Wanship, June 29, 1943 (*K*).

Needham and Christenson (1927: 25) give a brief account of the early stages as found in Logan River (emerged July 18, 1926). The larvae occurred

in the shelter of mixed mosses and algae at the water line, spinning silken pupal shelters in the same spots.

*Limonia (Dicranomyia) brevivena* (Osten Sacken, 1869).—A common and very distinct species, being one of the most characteristic forms that occur in the more arid regions. American Fork, on grass, June 15, 1937 (*Hansen*); Beaver Canyon, Puffers Lake, June 6, 1936 (*Hardy*); Cache Junction, July 2, 1913 (*H. R. Hagan*); Callao, August 8, 1945 (*K*); Circleville, July 9, 1943 (*K*); Cove, July 20, 1939 (*K*); Currant Creek, June 28, 1943 (*K & Telford*); Daniels Pass, July 25, 1945 (*K*); Eden, July 16, 1937 (*K*); Eden, July 16, 1937 (*Hardy*); Fish Springs, August 8, 1945 (*K*); Gandy, August 8, 1945 (*K*); Green River, June 14, 1945 (*K*); Hooper, May 25, 1939 (*K*), September 3-21, 1937 (*Hardy*); Huntsville, June 4, 1938 (*K & Stains*); Junction, June 28, 1945 (*K*); Koosharem, July 10, 1943 (*K & Telford*); Lehi, September 29, 1943 (*K & Maddock*); Liberty, October 9, 1937 (*Hardy*); Linwood, September 6, 1939 (*K & Harmston*); Logan, May 8, 1938 (*Hardy*), July 21, 1938, at light (*K & Hardy*); September 30, 1938 (*K & Nye*); Logan Canyon, October 26, 1945 (*Ted & Mary Tibbetts*); Manila, August 14, 1942 (*K*); Midway, August 14, 1943 (*K & Maddock*); Moab, June 13, 1945 (*K*); Monte Cristo, August 12, 1943 (*K & Maddock*); Morgan, July 24, 1945 (*K*); North Ogden Canyon, October 9, 1937 (*Hardy*); Parowan, August 8, 1942 (*K*); Payson, August 26, 1941 (*K*), August 26, 1943 (*K*); Pleasant Grove, July 26, 1937 (*Hansen*); Provo, June 8, 1939 (*K & Nye*); Riverton, on milkweed, June 18, 1937 (*Hansen*); Roy, June 16, 1945 (*K*); Salt Lake City, August 1, 1939 (*Rees*); Spanish Fork, June 8, 1936 (*Hardy*); Starr, June 29, 1945 (*K*); Strawberry Reservoir, July 25, 1945 (*K*); Mt. Timpanogos, July 26, 1945 (*K*); Zion National Park, 4,500 ft., June 21, 1942; Weeping Rock, July 9, 1943 (*K & Telford*), July 19, 1943 (*K*).

*Limonia (Dicranomyia) distans* (Osten Sacken, 1859).—Kanab, May 5, 1943 (*K*); Leeds, June 27, 1945 (*K*); Washington, June 27, 1945 (*K*).

*Limonia (Dicranomyia) gracilis* (Doane, 1900) (*halterella* Edwards, 1921).—Allen Canyon, August 12, 1943 (*K & Maddock*); Ferron Canyon, Willow Lake, September 1, 1945 (*Edmunds & Mulaik*); Huntington Canyon, 8,000 ft., September 1, 1945 (*Edmunds & Mulaik*); Mt. Timpanogos, Salamander Lake, August 26, 1943 (*K & Maddock*).

The name *gracilis* is a secondary homonym of *gracilis* Zetterstedt, 1838, and it may be advisable to use the later name *halterella*.

*Limonia (Dicranomyia) haeretica* (Osten Sacken, 1869).—Benjamin, June 21, 1945 (*K*).

*Limonia (Dicranomyia) halterata* (Osten Sacken, 1869).—Henefer, June 29, 1943 (*K & Telford*); Kimball's Fort, Silver Creek, June 29, 1943 (*K & Telford*); Sevier River, near Hatch, June 27, 1942.

*Limonia (Dicranomyia) humidicola* (Osten Sacken, 1859).—Hooper, July 7, 1937 (*Hardy*); Logan Canyon, October 14, 1945 (*K*); Mill Creek Canyon, June 24, 1938 (*K & Hardy*); Rockville, under rocks near bridge, June 28, 1945 (*K*); Salt Lake City, September 21, 1939 (*Rees*); Spanish Fork, June 14, 1936 (*Hardy*); Zion National Park, Weeping Rock, 4,500 ft., June 22, 1942; July 9, 1943 (*K & Telford*).

*Limonia (Dicranomyia) longipennis* (Schummel, 1829) (*immemor* Osten Sacken, 1861).—Cache Junction, May 25, 1944 (K); Charleston, August 14, 1943 (K & Maddock); Eden, June 21, 1937 (Hardy); Fish Haven, July 25, 1938 (D. E. & A. T. Hardy); Fish Lake, July 10, 1943 (K & Telford); Garden City, August 25, 1938 (K & Hardy); Heber, August 14, 1943 (K & Maddock); Hooper, September 17, 1937 (Hardy); Logan Meadows, June 13, 1944, October 15-17, 1943 (K); Wellsville, October 10, 1943 (K).

*Limonia (Dicranomyia) modesta* (Wiedemann, 1818) (*spinipectus* Alexander, 1924).—Hoytsville, October 10, 1943 (K). The first authentic record of this species from the United States.

*Limonia (Dicranomyia) penicillata* (Alexander, 1927).—Benjamin, June 21, 1945 (K & Telford); Cache Junction, May 27, 1944 (K); Corinne, June 19, 1944 (K, Wood & Stoddard); Redmond, May 4, 1943 (K); Salina, May 4, 1943 (K).

*Limonia (Dicranomyia) sera erostrata* (Alexander, 1930).—Blue Creek, May 31, 1939 (K); Saltair, Great Salt Lake, May 21 1926 (M. C. Van Duzee); types. This fly appears to be at most a race of the Palaearctic *L. (D.) sera* (Walker, 1848) (*Syn. disjuncta* Walker, 1848; *discors* Kuntze, 1919; *forcipula* de Meijere, 1919; *globata* Walker, 1848). Edwards indicates that in Europe the species frequents coastal marshes, indicating a saline or perhaps brackish habitat.

*Limonia (Dicranomyia) uinta* sp. nov.—Allied to *athabasca* and *spagnicola*; size large (wing, male, 7 mm. or more); rostrum yellow; praescutum with three conspicuous stripes, the broad median vitta narrowly divided behind, lateral stripes distinct; halteres elongate; male hypopygium with the caudal margin of tergite convexly rounded, with a narrow median notch, the apical lobes with a concentration of long setae; ventromesal lobe of basistyle with very conspicuous outgrowths and setal brushes, including a blackened lobe that is produced outwardly into a slender finger; rostral prolongation of ventral dististyle long and slender, arcuated, the two subappressed spines beyond midlength; gonapophysis with mesal-apical lobe unusually small and weak, the margins entirely smooth.

♂. Length, about 6.8-7 mm.; wing, 7-7.5 mm.

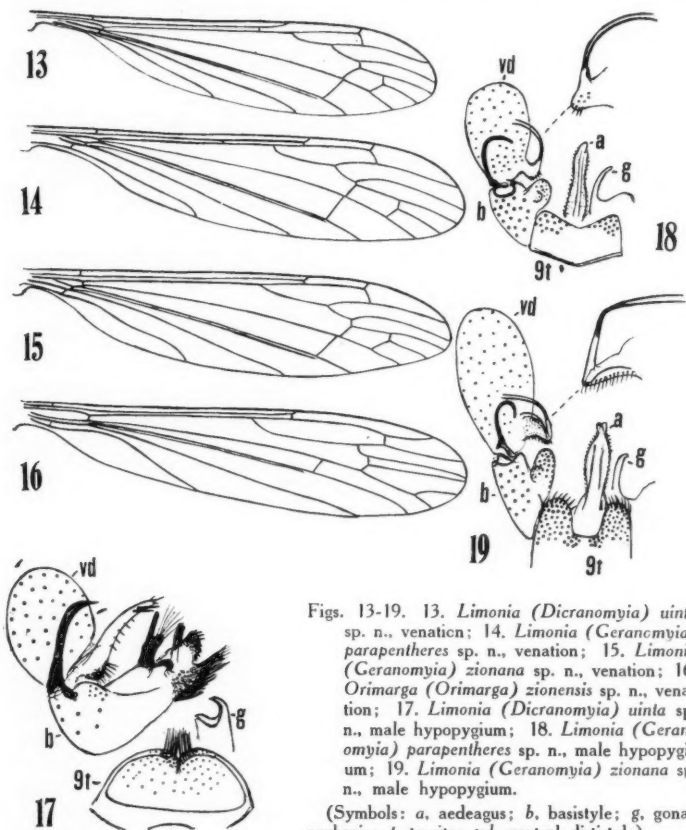
Rostrum yellow; palpi black, the basal segment yellow. Antennae black throughout; flagellar segments oval, the outer ones more elongate-oval to sub-cylindrical; terminal segment about one-fourth longer than the penultimate. Head above brownish gray, more ochreous behind and beneath; anterior vertex relatively wide.

Pronotum dark brown medially, obscure yellow on sides. Mesonotal praescutum in front golden-yellow, with a conspicuous brown median stripe that is divided into two points at the posterior end; lateral stripes narrower and somewhat paler, crossing the suture onto the scutal lobes; median region of scutum and the posterior sclerites of the notum more testaceous yellow. Pleura reddish yellow, the ventral sternopleurite somewhat more darkened. Halteres elongate, brownish black, the extreme base of stem yellow. Legs with the fore coxae weakly darkened, remaining coxae and trochanters obscure yellow; re-



mainder of legs yellowish brown to brown, the outer tarsal segments darker. Wings (Fig. 13) grayish subhyaline; stigma faintly darkened, relatively inconspicuous; veins brown, those of prearcular field paler. Venation:  $Sc_1$  ending opposite origin of  $R_s$ ,  $Sc_2$  some distance from its tip,  $Sc_1$  alone more than one-half  $R_s$ , in cases fully as long as distal section of vein  $M_3$ ;  $m-cu$  variable in position, from close to fork of  $M$  to some distance beyond, subequal in length to or longer than the distal section of  $Cu_1$ ; vein 2nd  $A$  gently sinuous.

Abdominal tergites dark brown, sternites obscure yellow; hypopygium dark-colored. Male hypopygium (Fig. 17) with the tergite,  $9t$ , large, the caudal margin convex, narrowly and weakly notched, lobes nearly contiguous, provided with numerous long setae that are concentrated near the midline to



Figs. 13-19. 13. *Limonia (Dicranomyia) uinta* sp. n., venation; 14. *Limonia (Geranomyia) parapentheres* sp. n., venation; 15. *Limonia (Geranomyia) zionana* sp. n., venation; 16. *Orimarga (Orimarga) zionensis* sp. n., venation; 17. *Limonia (Dicranomyia) uinta* sp. n., male hypopygium; 18. *Limonia (Geranomyia) parapentheres* sp. n., male hypopygium; 19. *Limonia (Geranomyia) zionana* sp. n., male hypopygium.

(Symbols: a, aedeagus; b, basistyle; g, gonapophysis; t, tergite; vd, ventral dististyle).

form strong brushes. Basistyle, *b*, with the ventromesal lobe large and complex, the area subequal to that of the style itself, the armature about as figured; most conspicuous is a blackened lobe that is produced into a long slender lobule or finger. Dorsal dististyle only gently curved, the tip acute. Ventral dististyle, *vd*, with the main body small, dark-colored; rostral prolongation long and slender, gently arcuated; spines two, subappressed, placed beyond mid-length of the prolongation. Gonapophysis, *g*, with mesal-apical lobe unusually small and weak, the margins entirely smooth.

*Holotype*, ♂, Logan, June 13, 1944 (G. F. Knowlton). *Paratypes* 2 ♂ ♂, Weber River, June 29, 1943 (G. F. Knowlton).

Although it is allied to both *Limonia* (*Dicranomyia*) *athabasca* (Alexander, 1927) and *L. (D.) sphagnicola* (Alexander, 1925), the present fly is amply distinct in the coloration and, especially, in details of structure of the male hypopygium. From the regional *athabasca* it differs in the structure of the tergite, basistyles and gonapophyses, in the last respect being more like *sphagnicola* of northeastern North America.

*Limonia* (*Geranomyia*) *canadensis* (Westwood, 1835).—Blanding, June 10, 1939 (K); Blue Creek, August 26, 1944 (K); Delta, August 25, 1943 (K); Garden City, August 12, 1943 (K); Hooper, September 21, 1937 (Hardy); Provo (Hardy); Rockville, beneath rocks near bridge, June 28, 1945 (K); Salt Lake City, August 8, 1936 (Rees); Zion National Park, Observation Point trail, 6,000 ft., July 3, 1942 (Degener & Peiler); see also *L. (G.) parapentheres* and *L. (G.) zionana*, below.

*Limonia* (*Geranomyia*) *diversa* (Osten Sacken, 1859).—Beaver, 7,000 ft., June 27, 1942; Zion National Park, Weeping Rock, May 5, 1945 (K).

*Limonia* (*Geranomyia*) *parapentheres* sp. nov.—Allied to *pentheres*; size small (wing, male, 6.3 mm.); rostrum short, about one-half the length of wing; femora obscure yellow, the tips narrowly infuscated; wings subhyaline, the oval stigma brown, conspicuous; *Sc*<sub>1</sub> ending about opposite midlength of *Rs*; male hypopygium with the caudal margin of tergite only slightly notched, the lobes correspondingly low, each provided with about 15 setae; ventral dististyle having about twice the area of the basistyle; rostral spines two, long and curved, arising from the summit of a slender tubercle; mesal-apical lobe of gonapophysis long and slender, pale.

♂. Length, excluding rostrum, about 5.5 mm.; wing, 6.3 mm.; rostrum, about 3.3.1 mm.

Rostrum relatively long, dark brown. Antennae dark brown throughout; flagellar segments subcylindrical, small, very gradually decreasing in length outwardly, the terminal segment a trifle shorter than the penultimate; verticils shorter than the segments. Head above dark brownish gray, the occipital region slightly brighter; anterior vertex narrow.

Cervical region dark brown. Pronotum light yellowish brown. Mesonotal praescutum light yellowish brown, more darkened medially, especially in front, but without lateral stripes; scutal lobes similarly darkened; median region of scutum light yellowish brown; scutellum brownish gray, with two small dark spots on basal portion; postnotum reddish brown, more or less darkened

medially. Pleura and pleurotergite uniformly reddish yellow, with a sparse whitish bloom, especially on posterior sclerites. Halteres with stem obscure yellow, knob dark brown. Legs with coxae and trochanters yellow; femora obscure yellow, the tips narrowly infuscated, the amount subequal on all legs; tibiae and tarsi brown, the outer tarsal segments black. Wings (Fig. 14) subhyaline, the oval stigma brown, conspicuous; veins brown. Venation:  $Sc_1$  ending about opposite midlength of  $R_s$ ,  $Sc_2$  near its tip; supernumerary cross-vein about the length of  $R_s$  before the origin of the latter; cell 1st  $M_2$  subequal in length to outer section of vein  $M_{1+2}$ ,  $m-cu$  close to fork of  $M$ ; cell 2nd  $A$  relatively narrow, vein 2nd  $A$  diverging only slightly from 1st  $A$ .

Abdomen brown, the bases or incisures of the segments somewhat paler; hypopygium with the ventral dististyle dark-colored. Male hypopygium (Fig. 18) with the tergite, 9t, transverse, the caudal margin with a broad V-shaped notch, the lobes low and relatively inconspicuous, each provided with about 15 setae. Basistyle,  $b$ , small, the ventromesal lobe with long pale setae and with a very small lateral lobule. Dorsal dististyle a slender, strongly curved rod, only a little longer than the rostral spines, the apex narrowly obtuse. Ventral dististyle,  $vd$ , having about twice the area of the basistyle, with sparse scattered setae; rostral prolongation short, the two long curved spines arising from a common tubercle that is placed a short distance back from the apex of the prolongation. Gonapophysis,  $g$ , with mesal-apical lobe pale, long and very slender. Aedeagus,  $a$ , microscopically setulose.

*Holotype*, ♂, Springdale, June 28, 1945 (G. F. Knowlton). *Paratypes*, ♂, Weeping Rock, September 7, 1945 (G. F. Knowlton); ♂♂, Zion National Park, Observation Point trail, 6,000 ft., July 3, 1942, "sucking nectar from Composite flowers", (Otto Degener), associated with *canadensis* and *zionana*.

This species and the following are readily separated from one another by the size, relative length of the rostra, and especially the structure of the male hypopygium, particularly the ninth tergite and the relative size of the ventral dististyle.

*Limonia* (*Geranomyia*) *zionana* sp. nov.—Allied to *penterhes*; size large (wings, 8 mm. or over); rostrum elongate, approximately two-thirds the length of wing; wings whitish subhyaline or glassy, the oval stigma pale brown;  $Sc_1$  ending about opposite two-thirds the length of  $R_s$ ; male hypopygium with the caudal margin of tergite deeply notched, the lateral lobes conspicuous, provided with abundant long black setae; ventral dististyle large and fleshy, its total area approximately two and one-half to three times that of the basistyle; rostral spines long and slender, curved, both arising from the summit of a single slender tubercle.

♂. Length, excluding rostrum, about 6.5-7 mm.; wing, 8-8.5 mm.; rostrum, about 5-6 mm.

♀. Length, excluding rostrum, about 8-8.5 mm.; wing, 8-8.5 mm.; rostrum, about 5.5-6 mm.

Rostrum very long, exceeding half the length of wing, light brown basally, becoming darker on outer two-thirds. Antennae with scape light brown,

pedicel reddish, flagellum brownish black; flagellar segments suboval to nearly cylindrical; verticils short and inconspicuous. Head ochreous on front and behind, the intermediate portion of vertex gray pruinose.

Pronotum testaceous brown. Mesonotal praescutum and scutum almost uniformly brownish yellow, with a gray pruinosity that is especially evident on the sides of the praescutum; scutal lobes similarly pruinose, the median region of scutum and the scutellum more testaceous; postnotum reddish brown, sparsely pruinose. Pleura and postnotum reddish brown. Halteres short, stem yellow, knob weakly infuscated. Legs with coxae and trochanters reddish brown; femora obscure yellow, the tips narrowly infuscated; tibiae and basitarsi brownish yellow, the tips narrowly darkened; outer tarsal segments brownish black. Wings (Fig. 15) whitish subhyaline or glassy, the oval stigma pale brown; veins obscure yellow or brownish yellow. Venation:  $Sc$  long,  $Sc_1$  ending nearly opposite three-fifths to two-thirds the length of  $R_s$ ,  $Sc_2$  near its tip; cell  $1st\ M_2$  subequal to or longer than the distal section of  $M_{1+2}$ ;  $m-cu$  a short distance before the fork of  $M$ ; vein  $2nd\ A$  gently sinuous, the cell wider than in *parapentheres*.

Abdomen obscure yellow to light brown, the sternites clearer yellow; hypopygium weakly brownish yellow. Male hypopygium (Fig. 19) with the tergal lobes,  $9t$ , very long and conspicuous, separated by a deep quadrate emargination, the lobes and sides of the notch with abundant black setae. Dorsal dististyle a strongly curved rod, its tip subacute. Ventral dististyle,  $vd$ , much larger than in *parapentheres*, being approximately two and one-half to three times the size of the basistyle; region of base of rostrum dilated and more heavily sclerotized than the remainder of lobe; rostral spines elongate, strongly curved beyond bases, arising from the summit of a single long slender basal tubercle. Gonapophysis,  $g$ , with mesal-apical lobe very slender, elongate. Aedeagus microscopically setulose.

*Holotype*, ♂, Zion National Park, Weeping Rock, 4,500 ft., June 21, 1942 (*M. M. Alexander*). *Allotype*, ♀. *Paratopotypes*, 2 ♀♀; *paratypes*, 6 ♂♂, Observation Point trail, 6,000 ft., July 3, 1942, "sucking nectar from Composite flowers", (*Otto Degener*), associated with *canadensis* and *parapentheres*.

The present fly, together with *Limonia* (*Geranomyia*) *parapentheres* sp. nov., have the male hypopygium quite distinct from the other members of the subgenus in the Nearctic fauna, though much as in various other species that center about *L. (G.) pentheres* Alexander, 1928, ranging from central Mexico to Peru. These two flies are quite distinct from these various Neotropical forms and from one another, as discussed under the preceding species.

*Limonia* (*Alexandriaria*) *suffusca* (Garrett, 1922).—A female, Circleville, June 28, 1945 (*K*). I am referring the specimen to this species with some question. Garrett (1922) described three supposed new species that evidently represent a single form, *suffusca* being the oldest name and, at the same time, type of the subgenus *Alexandriaria* Garrett. Through the appreciated interest of Mr. Garrett, I have been able to purchase the type material of his species

in the Tipulidae. From present evidence it would seem that *L. (A.) whartoni* (Needham, 1908) is distinct and the possibility is not excluded that the present female may belong to this species.

*Antocha (Antocha) monticola* Alexander, 1917.—Avon Canyon, August 24, 1942 (K); Blacksmith Fork Canyon, June 12, 1938 (K & Hardy); Brigham Canyon (no collector); Eden, June 8, 1938, in meadow (K & Hardy), July 10, 1937 (Hardy); Hooper, September 21, 1937 (Hardy); Huntington Canyon, 6,000 ft., September 1, 1945 (Edmunds & Mulaik); Kaysville, June 2, 1945 (K); Logan, June 9, 1943 (Maddock), July 8, 1938 (Hardy), July 26, 1938, at light (K & Hardy), August 4, 1942 (K & Roberts), July 28–August 3, 1943, abundant (K), August 19, 1942 (K & Roberts), September 13, 1943 (K); Logan Canyon, June 30, 1942, July 4, 1945 (K), July 23, 30, August 8, 1945 (K); Mantua, September 4, October 10, 1943 (K); Ogden July 3, 1937 (Hardy); Salt Lake City, Fairmont Park, August 4, 31, 1939 (Rees). Very common and eminently characteristic in Logan Canyon, as discussed by Needham and Christenson (1927: 24-25), who give a brief account of the habitat and habits of the immature stages, with figures of the larva and pupa.

*Elliptera astigmatica* Alexander, 1912.—Provo Canyon, North Fork (Hardy); Mt. Timpanogos, Aspen Grove (Hardy), Glacier Lake (Hardy).

*Dicranoptycha quadrivittata* Alexander, 1919.—Beaver Canyon, 7,200 ft., July 12, 1945 (K & Telford); Monte Cristo, July 24, 1943 (K & Maddock).

*Orimarga (Orimarga) zionensis* sp. nov.—General coloration gray, the praescutum with four inconspicuous more plumbeous gray stripes; femora obscure yellow, the tips conspicuously brownish black; wings with a strong blackish suffusion, the preacular field more whitened; macrotrichia on outer radial and medial veins;  $R_{1+2}$  about one-half longer than  $R_{2+3}$ ; cell  $M_3$  small;  $m-cu$  from two to three times its own length before the fork of  $M$ .

♂. Length, about 5.5-6 mm.; wing, 5-6 mm.

♀. Length, about 5.5-6 mm.; wing, 5-5.5 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments oval. Head dark gray.

Pronotum gray. Mesonotal praescutum gray, with four darker plumbeous gray stripes, the pale median vitta only about one-third as wide as either intermediate stripe; posterior sclerites of notum gray, the scutal lobes with more plumbeous gray areas. Pleura light gray, vaguely striped with more brownish areas, including a more dorsal line from the fore coxae to the root of the halteres; ventral sternopleurite more broadly infuscated. Halteres with stem yellow, knob brownish black. Legs with the coxae yellowish brown, the fore pair somewhat darker; femora obscure yellow, the tips conspicuously brownish black, the amount subequal on all legs; tibiae and basitarsi light brown, the tips very narrowly darker; outer two tarsal segments more blackened. Wings (Fig. 16) with a strong blackish suffusion; preacular field more whitened; veins brown. Macrotrichia on veins  $R_{1+2}$ ,  $R_3$ , distal section of  $R_{1+5}$ , outer half of distal section  $M_{1+2}$ ,  $M_3$  and  $M_4$ . Venation:  $Sc_1$  ending about opposite two-fifths the length of  $R_5$ ,  $Sc_2$  near its tip; free tip of  $Sc_2$  weakly preserved:

$R_{1+2}$  elongate, about one-half longer than  $R_{2+3}$ ; inner end of cell  $R_3$  slightly arcuated; cell  $R_5$  narrowed toward its outer end; cell  $M_3$  about one-half its petiole;  $m-cu$  variable in position, from about two to three times its own length before the fork of  $M$ ; vein 2nd  $A$  unusually arcuated, the cell very wide. Several of the type series show abnormalities in venation, more notably the presence of adventitious crossveins in cells  $R_2$ ,  $R_3$  and  $R_{5+1}$ , especially the last where as many as three such veinlets may occur in a single wing; other abnormalities include angulation and spurring of the basal section of  $R_{4+5}$  and an occasional angulation and spurring of the base of  $R_5$ . Abdomen black, the subterminal sternites somewhat brightened.

*Holotype*, ♂, Weeping Rock, Zion National Park, 4,500 ft., June 21, 1942 (*M. M. Alexander*). *Allotopotype*, ♀, pinned with type. *Paratopotypes*, several ♂♀, June 21-23, 1942 (*C. P. & M. M. Alexander*).

The nearest relative is *Orimarga (Orimarga) sanctae-ritae* Alexander, 1946, of southeastern Arizona, which differs conspicuously in all details of venation, including the unusually distal position of  $m-cu$ . The species was abundant at the Weeping Rock, usually found resting on grass blades. An unusual number were found caught in spider webs, one still with its cast pupal case attached. A few mating pairs were observed. When at rest, the species holds its wings incumbent over the back and thus presents an unusually slender appearance.

#### PEDICIINI

*Pedicia (Tricyphona) exoloma* (Doane, 1900).—Beaver, 8,000 ft., June 21-22, 1942.

*Pedicia (Tricyphona) septentrionalis* (Bergroth, 1888), var.—Allen Canyon, July 24, 1943 (*K & Maddock*); Beaver Canyon, 7,200 ft., July 12, 1945 (*K & Telford*); Devils Slide, August 14, 1943 (*K & Maddock*); Eden, June 23, 1938 (*Hardy & Stains*); Heber, August 14, 1943 (*K & Maddock*); Henefer, August 30, 1943 (*K*); Logan Canyon, June 30, 1942 (*M. A. Alexander*) July 8, 1938 (*Hardy*); Orem, July 26, 1945 (*Harmston*); Strawberry Reservoir, July 25, 1945 (*K*); Weber River, June 29, 1943 (*K*); Wellsville, October 17, 1945 (*George & Mary Knowlton*). The exact identity of this species remains in doubt, due primarily to the fact that the types of Bergroth's species are in Finland and unavailable. It now appears that Bergroth's name pertains to a single variable species or group of allied forms, to which may be added *Pedicia (Tricyphona) vitripennis* (Doane, 1901), *P. (T.) cervina* (Alexander, 1917) and *P. (T.) sparsipuncta* (Alexander, 1920).

*Dicranota (Plectromyia) petiolata* (Alexander, 1919) (*nemoptera* Alexander, 1927; *stenoptera* Alexander, 1927).—Ephraim Canyon, near summit, September 6, 1945 (*K*); Huntsville, August 21, 1942 (*K, Roberts & Wood*). Kents Lake, July 12-13, 1945 (*K*); Monte Cristo Canyon, August 25, 1938 (*K & Hardy*); Strawberry Reservoir, July 25, 1945 (*K*); Mt. Timpanogos, July 26, 1942 and 1945 (*K*), Glacier Lake (*Hardy*), Timponee Ranger Station, August 26, 1943 (*K & Maddock*); Wolf Creek Pass, near summit, July 24, 1945 (*K*).

A most puzzling series of these flies was taken by Knowlton, showing all stages in wing reduction, with corresponding venation. The structure of the male hypopygium is very constant, however, and it now seems evident that the synonymy as given above is correct. This condition of wing atrophy was found in both sexes, reaching its culmination in a long straplike structure, with the venation correspondingly distorted. The type of *nemoptera* was taken at Peterson's Spring, Logan Canyon, 7,500 ft., July 20, 1926, by Dr. J. G. Needham, and originally was placed in the genus *Limnophila*. The present series serves well to interconnect these various supposed species.

*Dicranota (Dicranota) montana* (Alexander, 1920).—Logan, April 17, 1938 (K & Hardy).

*Dicranota (Dicranota) stainsi* sp. nov.—Size large (wing, female, over 9 mm.); general coloration gray, the praescutum with four brown stripes; antennae black throughout, basal flagellar segments very short-oval, the outer ones a little longer; wings hyaline, stigma medium brown; *Rs* very short, angulated and long-spurred beyond midlength; basal section of  $R_{4+5}$  longer than basal section of  $R_5$ ; cell 1st  $M_2$  closed; cell  $M_1$  about one-third longer than its petiole; *m-cu* at fork of *M*; Anal cells very broad; abdomen gray, the tergites with a broad bright brown central stripe.

♀. Length, about 7 mm.; wing 9.1 mm.

Rostrum dark gray; palpi brownish black. Antennae black throughout; basal flagellar segments very short oval, the outer ones a little longer; terminal segment or segments broken. Head gray, the center of vertex infuscated.

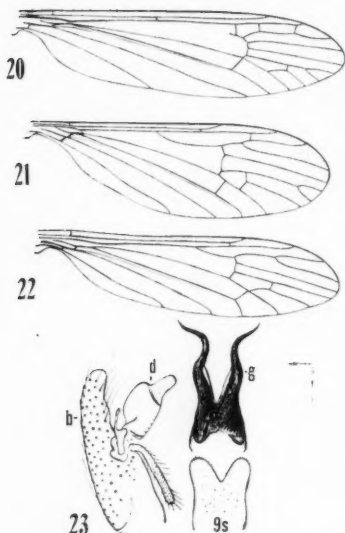
Pronotum gray, more infuscated medially. Mesonotal praescutum gray, with four brown stripes, the broad intermediate pair separated only by a capillary brownish gray median vitta; lateral stripes much narrower; posterior sclerites of notum gray, each scutal lobe with two grayish brown areas. Pleura clear gray. Halteres with stem obscure yellow, clearer basally, knob weakly infuscated. Legs with coxae gray; trochanters brownish gray; remainder of legs light brown, the tips of femora and tibiae narrowly more infuscated; terminal tarsal segments blackened. Wings (Fig. 20) hyaline, the base restrictedly more yellowed; stigma medium brown, in cell  $R_1$  confined by the two transverse veins; veins brown. Venation:  $Sc_1$  ending about opposite one-fifth the length of stigma,  $Sc_2$  just beyond mid-distance between arculus and origin of *Rs*; *Rs* very short, angulated beyond midlength, with a long conspicuous spur at the point of angulation, jutting back into cell *R*; basal section of  $R_{4+5}$  longer than the basal section of  $R_5$ ; cell  $M_1$  about one-third longer than its petiole; cell 1st  $M_2$  closed, long and narrow; *m-cu* at fork of *M*; Anal cells very broad.

Abdomen gray, the tergites with a broad and conspicuous bright brown central stripe that is interrupted by the narrow yellow posterior borders of the more proximal segments.

*Holotype*, ♀, Garden City, June 6, 1938 (Knowlton & Harmston); Alexander Collection.

This interesting fly is named in honor of Mr. G. S. Stains, who collected





numerous Tipulidae in conjunction with Professor Knowlton. The fly is so different from all other regional species that little comparison seems necessary. The very distinct venational details, especially the short angulated and spurred  $R_s$ , closed cell 1st  $M_2$  and position of  $m-cu$  at the fork of  $M$ , all mark the species as being isolated.

Figs. 20-23. 20. *Dicranota (Dicranota) stainsi* sp. n., venation; 21. *Oxydiscus (Oxydiscus) maddocki* sp. n., venation; 22. *Phyllolabis zionensis* sp. n., venation; 23. *Phyllolabis zionensis* sp. n., male hypopygium.

(Symbols: b, basistyle; d, dististyle; g, gonapophysis; s, sternite).

*Dicranota (Rhaphidolabis) cayuga* (Alexander, 1916).—Brigham Canyon. October 10, 1943 (K); Logan Canyon, July 17, 1938 (Hardy).

*Dicranota (Rhaphidolabis) cazieriana* Alexander, 1944.—Allen Canyon, August 12, 1942 (K); Sardine Canyon, May 21, 1938 (Hardy). Hitherto only from California.

*Dicranota (Rhaphidolabis) integriloba* Alexander, 1943.—Logan Canyon, Spring Hollow, July 5, 1943 (K & Maddock).

*Dicranota (Rhaphidolabis) neomexicana* (Alexander, 1912).—Mantua, September 4-13, 1943 (K); Salt Lake City, City Creek Canyon, June 30, 1945 (K).

*Dicranota (Rhaphidolabis) querula* Alexander, 1944.—Rocky Mouth Canyon, October 1, 1945 (Edmunds).

#### HEXATOMINI

*Oxydiscus (Oxydiscus) maddocki* sp. nov.—General coloration dull black; wings with a brownish tinge, the oval stigma still darker; sparse macrotrichia in outer ends of cells  $R_2$  to  $M_4$ , inclusive;  $R_{2+3+4}$  nearly three times  $R_{2+3}$ ; cell  $M_1$  present but small; cell 1st  $M_2$  small, widened outwardly,  $m-cu$  from one-half to two-thirds its own length beyond the fork of  $M$ .

♀. Length, about 5 mm.; wing, 4.8 mm.

Rostrum and palpi black. Antennae with scape and pedicel black; flagellum broken. Head dull black.

Thorax dull black throughout, with praescutal stripes. Halteres brownish black, the base of stem pale. Legs with the coxae and trochanters brownish

black; remainder of legs broken. Wings (Fig. 21) with a brownish tinge, the oval stigma still darker. Sparse macrotrichia in outer ends of cells  $R_2$  to  $M_4$ , inclusive (their position indicated in figure by stippling). Venation:  $Sc_1$  ending opposite fork of  $Rs$ ,  $Sc_2$  some distance from its tip,  $Sc_1$  alone about equal to the arcuated  $r-m$ ;  $R_{2+3+4}$  nearly three times  $R_{2+3}$ , the latter subequal to  $R_2$ ; cell  $M_1$  present but small; cell 1st  $M_2$  small, short-rectangular, widened outwardly;  $m-cu$  about one-half to two-thirds its length beyond the fork of  $M$ .

Abdomen black, the genital shield brownish black. Ovipositor with both cerci and hypovalvae long and slender, yellowish horn color.

*Holotype*, ♀, Zion National Park, Weeping Rock, 4,500 ft., July 19, 1943 (Knowlton & Maddock); Alexander Collection. *Paratype*, 1 ♂, June 29, 1940 (A. L. Melander); Melander Collection; received too late for fuller discussion in the above description.

*Oxydiscus* (*Oxydiscus*) *maddocki* is named in honor of Mr. Darrell R. Maddock, who has collaborated with Professor Knowlton in making the present collection of Tipulidae of Utah. This species is quite distinct from all of the other American species in the uniformly black coloration of the body and the coloration of the wings. All other Nearctic species are brown to yellow in color, with clear wings. Various members of the genus are now known both in eastern and in western North America and in Central and South America, as far south as Ecuador.

*Oxydiscus* (*Oxydiscus*) *pacificus* Alexander, 1944.—Logan, June 9, 1943 (*Maddock*). A single female but the identity seems to be certain.

*Phyllolabis zionensis* sp. nov.—General coloration of thorax brownish yellow to yellow, the praescutum with a more or less distinct median brown stripe; rostrum and mouthparts yellow; antennae with the scape yellow, flagellum brown; femora obscure yellow to brownish yellow; wings faintly tinged with yellow, stigma oval, very pale brown; male hypopygium with the sternal plate moderately broad, parallel-sided, the caudal margin with a deep V-shaped notch; basistyle with the outer apical angle produced into a simple lobe; dististyle strongly narrowed and setiferous on outer two-thirds; gonapophyses unusually strong and powerful, appearing as sinuous rods that narrow to the acute tips; ovipositor with cerci slender, the margins smooth.

♂. Length, about 7 mm.; wing, 6.8 mm.

♀. Length, about 7 mm.; wing, 7 mm.

Rostrum and mouthparts light yellow; palpi with basal segment yellow, outer segments passing into brown. Antennae with scape yellow; pedicel yellow basally, more infuscated outwardly; flagellum brown, the segments subcylindrical. Head gray; anterior vertex moderately wide, more than three times the diameter of scape.

Pronotum obscure brownish yellow. Mesonotal praescutum brownish yellow with a more or less distinct median brown stripe, clearly defined in the holotype; scutal lobes weakly darkened; posterior sclerites of notum more uniformly testaceous yellow. Pleura, including the dorsopleural membrane, pale yellow, the ventral sclerites very vaguely more darkened. Halteres yellow,

the knobs weakly infuscated. Legs with the coxae and trochanters yellow; femora obscure yellow to brownish yellow, the tibiae gradually deepening to brown. Wings (Fig. 22) with a very faint yellowish tinge, the prearcular and costal fields clearer yellow; stigma oval, very pale brown; veins brown, more yellowed in the brightened portions. Macrotrichia of veins long and conspicuous. Venation:  $Sc_1$  ending a short distance beyond the fork of  $R_s$ ,  $Sc_2$  before this fork;  $R_{2+3+4}$  subequal to or longer than  $R_s$ , about as long as vein  $R_3$ ;  $m-cu$  at or just before the fork of  $M_{3+4}$ .

Abdomen brown in male, brownish yellow in female; in male, base of ninth segment more darkened. Ovipositor with cerci long and slender, the margins smooth. Male hypopygium (Fig. 23) of unusually generalized structure for a member of this genus. Appendage of ninth sternite,  $9s$ , a flattened-depressed pale plate, its caudal margin with a deep V-shaped notch, the slightly divergent apical lobes obtusely rounded, densely clothed with very delicate pale setae; surface of plate with a few scattered longer setae. Basistyle,  $b$ , with outer apical angle produced into a lobe that is slightly longer than the dististyle, at the obtuse apex flattened and glabrous; ventral lobe of basistyle long and pendulous, pale, with long setae. What appears to represent a distinct upper dististyle is a small flattened blade that narrows into a slender arm, the tip obtuse and weakly dilated; the larger dististyle,  $d$ , very simple, the enlarged basal two-thirds expanded into a pale entire dorsal crest, the beak stout, with numerous setigerous punctures, its tip obtuse; beak delimited from main body of style by a wrinkled or corrugated transverse line. Gonapophyses,  $g$ , unusually strong and powerful, dark reddish brown, each appearing as a sinuous rod that narrows very gradually to the acute tip.

*Holotype*, ♂, Zion National Park, 4,500 ft., May 18, 1944 (G. F. Knowlton). *Allotype*, ♀, The Narrows, June 21, 1942 (C. P. Alexander).

*Phyllolabis zionensis* is readily told from the other rather numerous Nearctic species by the unusually primitive structure of the male hypopygium. In its pale coloration, the fly superficially resembles *P. flavida* Alexander, of extreme southern California. Among those Nearctic species at present known, the following are the most distinct and isolated—*P. encausta* Osten Sacken, 1877; *P. flavida* Alexander, 1918; *P. lagganensis* Alexander, 1931; *P. myriosticta* Alexander, 1945, and the present fly.

*Dactylolabis knowltoni* Alexander, 1943.—Logan Dry Canyon, June 24, 1938 (K & Nye), type material; Mirror Lake, Uinta Mountains (Hardy); Monte Cristo, July 21, 1942 (K).

*Limnophila (Elaeophila) aldrichi collata* subsp. nov.—Generally similar to typical *aldrichi* Alexander, 1927, of the northern Rocky Mountains, differing in relatively slight details of coloration and structure of the male hypopygium.

♂. Length, about 7.5-8 mm.; wing, 8-8.5 mm.

♀. Length, about 8.5-9 mm.; wing, 9-9.5 mm.

Wings with the ground pale yellow, with a conspicuous dark brown pattern that is restricted to the vicinity of the veins, these areas usually more restricted and concentrated than in *aldrichi*. Male hypopygium with the outer

dististyle much the same in both races, including the dorsal crest. Inner dististyle conspicuously narrowed, especially at apex, the actual tip bearing a single seta, the other being removed from this tip; in typical *aldrichi*, the apex is broadly obtuse, there being four or five setae on this bluntly rounded portion. Some of the paratypes are smaller (♂. Wing, 7 mm.; ♀. Wing, 6.5 mm.) but evidently pertain to this same subspecies. The race *alticrista* Alexander, 1943, is less closely related to either of the above.

*Holotype*, ♂, Beaver, 8,000 ft., June 26, 1942 (C. P. Alexander). *Allotopotype*, ♀. *Paratopotypes*, 3 ♂♀, June 25-26, 1942; *paratypes*, 1 ♂, Mt. Timpanogos, Glacier Lake (Hardy); 1 ♀, Mt. Timpanogos, environs of Aspen Grove (Hardy).

*Limnophila (Elacophila) aleator* Alexander, 1945.—Glendale, May 5, 1943 (K); part of type material.

*Limnophila (Elacophila) angustior* Alexander, 1919.—Brigham, June 17, 1938 (Hardy & Stains); Currant Creek, 7,200 ft., among willow and nettle, June 28, 1945 (K); Fairview, July 7, 1945 (Edmunds & Mulaik); Glendale, June 28, 1945 (K); Logan Canyon, June 30, 1942, July 29, 1945 (K), July 30, 1945 (K).

One of the Glendale females is of unusual interest in that the supernumerary crossvein in cell *M* is lacking in both wings. In all other respects the fly is quite like typical material and I regard the identification as certain.

*Limnophila (Prionolabis) rufibasis* Osten Sacken, 1859.—Spanish Fork, without date (D. Elmo Hardy). There is no doubt of the identity of this material. If there is no mistake in the distributional data, the present record greatly extends the known range of the species.

*Limnophila (Phylidorea) auripennis* Alexander, 1926.—Fort Duchesne, July 25, 1945 (K).

*Limnophila (Phylidorea) bigladi* Alexander, 1945.—Logan Canyon, 5,200 ft., June 30, 1942.

*Limnophila (Phylidorea) claggi* Alexander, 1930.—Brigham City, May 25, 1945 (Harmston); Logan Canyon, Spring Hollow, July 5, 1943 (K); Maple Pass, June 5, 1939 (K & Harmston); Salt Lake City, May 29, 1945 (Harmston).

*Limnophila (Phylidorea) nycteris* Alexander, 1943.—Logan Canyon, China Row Camp, June 30, 1942.

*Limnophila (Phylidorea) tepida* Alexander, 1926.—Amalga, May 30, 1940 (K); Daniels Pass, July 25, 1945 (K); Garden City, August 11, 1942 (K), August 24, 1941 (Mulaik), August 25, 1938 (K & Hardy); Lewiston, April 27, 1938 (Hardy); Logan Canyon, June 18, 1938 (Hardy); Ogden, July 7, 1937 (Hardy); Spanish Fork, June 14, 1936 (Hardy); Strawberry Reservoir, along stream, July 25, 1945 (K); Wellsville, in meadow swamps, August 10, 1938 (K & Harmston), September 4, 1943 (K).

*Limnophila occidentis* Alexander, 1924.—Logan, June 29, 1943 (Maddock); Logan Canyon, Spring Hollow, July 5, 1943 (K), July 17, 1938 (Hardy);

River Heights, August 14, 1942 (*K & Wood*); Zion National Park, Weeping Rock, May 5, 1943 (*K*). The specimen from River Heights is smaller than the types and other specimens from high altitudes in Colorado.

*Shannonomyia osleri* (Alexander, 1916).—Wolf Creek Canyon, June 24, 1945 (*K*).

*Pilaria imbecilla* (Osten Sacken, 1859).—Bear Lake, June 30, 1942; Wolf Creek Canyon, July 24, 1945 (*K*).

*Pilaria recondita* (Osten Sacken, 1869).—American Fork, June 21, 1938 (*K & Hardy*); Beaver, June 27, 1945 (*K*), July 11, 1945 (*K & Telford*); Brigham, June 17, 1938 (*Hardy & Stains*); Callao, August 7, 1945 (*K*); Charleston, August 14, 1943 (*K & Maddock*); Eden, June 23, 1938 (*Hardy & Stains*), July 16, 1937 (*Hardy*); Fish Springs, August 8, 1945 (*K*); Garden City, August 12, 1943 (*K*); Granite Creek, August 7, 1945 (*K*); Heber, August 14, 1943 (*K & Maddock*); Huntsville, June 23, 1938 (*Hardy & Stains*); Kamar, July 24, 1945 (*K*); Leeds, August 8, 1942 (*K & Peay*); Monte Cristo, August 12, 1943 (*K & Maddock*); Mt. Nebo, July 25, 1942 (*K*); Nephi, June 29, 1945 (*K*); Ogden, June 12, 1945 (*Harmston*); Peoa, July 24, 1945 (*K*); Providence, July 2, 1943 (*Telford*); Starr, June 29, 1945 (*K*); Mt. Timpanogos, Pleasant Grove, July 1, 1937 (*K & Hansen*); Wellsville, in meadow swamps, July 21, 1942 (*K*), August 10, 1938 (*K & Harmston*); Woodland, July 24, 1945 (*K*).

*Hexatoma (Eriocera) austera* (Doane, 1900).—Henefer, June 29, 1943 (*K*). A single male that has the wings very reduced in size but approached by other specimens from the Yellowstone. Free flight would not be possible in such individuals.

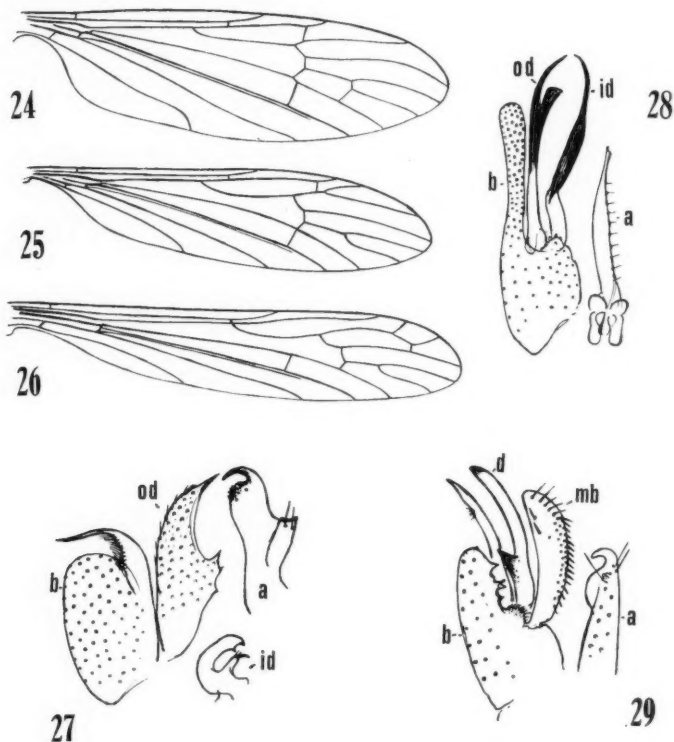
*Hexatoma (Eriocera) eriophora* (Williston, 1893).—Eden, in meadow, June 8, 1938 (*K & Hardy*); Logan Canyon, at light, July 3, 1939 (*K*), July 23, 1945, July 29, 1939, August 8, 1945 (*K*); Monroe Canyon, June 1930 (*Rowe*); Provo, 4,750 ft., July 29-August 1, 1920; American Museum of Natural History, F 4757.

*Hexatoma (Eriocera) velveta* (Doane, 1900).—Blacksmith Fork Canyon, June 12, 1938 (*Hardy*); Brigham, June 17, 1938 (*Hardy & Stains*); Eden, June 8, 1938 (*K & Hardy*); Fish Lake, June, 1930 (*Rowe*); Kanosh Canyon, May 27, 1939 (*K & Harmston*); Mirror Lake, Uinta Mts. (*Hardy*); Provo Canyon, North Fork (*Hardy*); Salt Lake City, July 2, 1939 (*K*); Zion National Park, May 13, 1936 (*Rees & Duncan*).

#### ERIOPTERINI

*Teucholabis (Teucholabis) rubescens* Alexander, 1914.—Zion National Park, 4,500 ft., June 21, 1942 (*C. P. & M. M. Alexander*). At the Grotto Campground, between 7 and 9 P. M., several specimens were found, usually in groups of from three to five individuals, swarming close to the ground, usually within a foot or two. Almost invariably they swarm about the trunk of a tree, including the cottonwood, *Populus fremontii pubescens* Sargent, the desert or velvet ash, *Fraxinus velutina* Torrey, and the box elder, *Acer negundo*

*interius* (Britton) Sargent. In some cases a single male would go through all the swarming motions. Almost always the flies were only two or three inches distant from the boles of the tree. A few mated pairs were found, flying through the air while still united. It might be observed that the type of the species was found some half a century ago in the White Mountains, New Mexico, by the late C. H. T. Townsend, who found it swarming about the trunk of a mountain cottonwood, evidently a habit very much as above described.



Figs. 24-29. 24. *Teucholabis (Teucholabis) rubescens* Alexander, venation; 25. *Gonomyia (Progonomyia) zionicola* sp. n., venation; 26. *Gonomyia (Euptilostena) knowltoniana* sp. n., venation; 27. *Teucholabis (Teucholabis) rubescens* Alexander, male hypopygium; 28. *Gonomyia (Euptilostena) knowltoniana* sp. n., male hypopygium; 29. *Gonomyia (Progonomyia) zionicola* sp. n., male hypopygium.

(Symbols: a, aedeagus; b, basistyle; d, dististyle; id, inner dististyle; mb, mesal lobe of basistyle; od, outer dististyle).

The wing venation is illustrated (Fig. 24). The sternal pockets on the male abdomen are conspicuous, especially on the fifth segment, where it consists of a shield-shaped darkened area with numerous small blackened tubercles and fewer long scattered setae, the largest and most conspicuous of these marginal in position and directed inwardly, decussate at the midline. On sternite six on either side of the broad central area with a row of from seven to eight very long setae directed mesad, these interspersed with fewer smaller bristles. Male hypopygium (Fig. 27) with the spine of the basistyle, *b*, broad to very broad at base, narrowed very gradually into a long slender blackened point, the lower margin before this with a fringe of yellow setae; mesal flange narrowly blackened, its cephalic portion somewhat more produced. Outer dististyle, *od*, broad, tapering gradually to a small apical spine, the lower edge at near midlength more or less produced into an irregular lobe or flange. Inner dististyle, *id*, small, the long outer lobe unequally bidentate; more basally with a smaller slender lobule that terminates in a long blackened spine. Aedeagus, *a*, conspicuous, appearing as a compressed-flattened blade that terminates abruptly in a curved blackened spine; posterior margin of organ at near midlength slightly produced and bearing two long setae.

*Gonomyia (Progonomyia) zionicola* sp. nov.—General coloration brownish gray and yellow; antennae brownish black throughout; wings pale yellowish subhyaline, stigma very pale brown;  $Sc_1$  ending about opposite midlength of  $R_s$ ,  $Sc_2$  some distance from its tip; male hypopygium with the outer lobe of basistyle stout, its mesal edge produced into a glabrous plate that is very coarsely toothed; outer dististyle pointed at apex, with a few setae at near two-thirds the length; inner style with a blackened triangular tooth at about the basal third.

♂. Length, about 5 mm.; wing, 6 mm.

♀. Length, about 6 mm.; wing, 6.5 mm.

Rostrum and front yellow; palpi dark brown. Antennae brownish black throughout; flagellar segments long-oval. Head light gray.

Pronotum and pretergites light yellow, the former darker laterally. Mesonotum brownish gray, the humeral and lateral portions of praescutum light yellow; posterior portions of scutal lobes and the caudal border of scutellum yellowed; mediotergite dark gray, the anterolateral borders and the dorsal pleurotergite broadly yellow. Pleura dark reddish brown, sparsely pruinose, with a conspicuous yellow longitudinal stripe in male, not evident in female. Halteres infuscated, the basal half of stem yellow. Legs with the coxae reddish yellow; trochanters yellow; femora and tibiae brownish yellow, the tips of the latter narrowly darkened; tarsi brownish black. Wings (Fig. 25) very pale yellowish subhyaline, the prearcular and costal portions somewhat clearer yellow; stigma oval, very pale brown; veins light brown. Venation: *Sc* long,  $Sc_1$  ending about opposite midlength of  $R_s$ ,  $Sc_2$  some distance from its tip, about opposite one-fourth the length of  $R_s$ ; vein  $R_2$  very weakly preserved, a little longer than vein  $R_{3+4}$ ; cell  $R_3$  deep; cell 2nd  $M_2$  about one-half longer than its petiole; *m-cu* at fork of *M*; vein 2nd *A* not sinuous.



Abdomen brown in male, dark brown in female; genital segment of female yellow. Ovipositor with valves elongate, yellowish horn color. Male hypopygium (Fig. 29) yellow; outer lobe of basistyle, *b*, relatively short and stout, its mesal edge produced into a coarsely toothed glabrous plate or flange; mesal lobe, *mb*, much longer, extending caudad about to the outermost level of the dististyles. Dististyles, *d*, two in number, subequal in length, the outer one more pointed at apex, with a few scattered setae at near two-thirds the length; inner style with a blackened triangular tooth or flange at near the basal third and here provided with several delicate setulae. Aedeagus, *a*, terminating in a pale curved crook, before which is a conspicuous expanded flange.

*Holotype*, ♂, Zion National Park, 4,500 ft., June 21, 1942 (C. P. Alexander). *Allotopotype*, ♀, pinned with the type. *Paratopotypes*, 2 ♂♂, a broken specimen, Washington, June 10, 1936 (Rees).

The present fly is most similar to *Gonomyia* (*Progonomyia*) *hesperia* Alexander, 1926, and *G. (P.) slossonae* Alexander, 1914, differing especially in the details of structure of the male hypopygium, particularly of both dististyles.

*Gonomyia* (*Euptilostena*) *knowltoniana* sp. nov.—Allied to *dampfiana*; mesonotum gray, the praescutum with four brown stripes; thoracic pleura gray, striped with light yellow, the latter areas narrowly bordered by dark brown; wings whitish subhyaline, restrictedly patterned with brown; male hypopygium with the outer lobe of basistyle, elongate, with numerous setae; both dististyles longer than the lobe of basistyle, the inner one appearing as a narrow blade, its apical third narrowed into a spine.

♂. Length, about 5 mm.; wing, 5.5 mm.

♀. Length, about 6-6.5 mm.; wing, 6-6.5 mm.

Rostrum and palpi black. Antennae brownish black to black, in some females the flagellar segments weakly bicolored, brownish black, the tips obscure yellow; flagellar segments long-oval. Head above light yellow in front, gray behind, with a narrow brown median vitta on vertex.

Pronotum brownish gray medially above, narrowly light yellow on sides; pretergites yellow. Mesonotal praescutum gray, with four brown stripes, the intermediate pair separated by a ground vitta of about one-half their own width; pseudosutural foveae dark brown; scutum gray, each lobe with two brown areas, the smaller outer mark being a continuation of the lateral praescutal stripe; a capillary median brown vitta on scutum; scutellum brown, with a pale yellow central spot; postnotum dark gray. Pleura gray, striped longitudinally with light yellow, the latter including the dorsopleural area and a broader and more conspicuous line from the fore coxae backward, expanded behind, the pale areas narrowly bordered by dark brown; expanded portion of the lower pale stripe more or less lined with brownish black. Halteres with the stem yellow, knob brownish black. Legs with the fore coxae chiefly whitened on outer face; middle and posterior coxae brownish gray, the tips broadly yellow; trochanters obscure brownish yellow; femora obscure yellow, the tips gradually more infuscated, relatively narrow, subequal in amount on all

legs; tibiae brownish yellow, the tips narrowly dark brown; tarsi brown, passing into brownish black. Wings (Fig. 26) whitish subhyaline, clearer white in the prearcular and costal fields, the latter including marginal spots in the outer radial field; a conspicuous but restricted brown pattern, including the arculus; origin of  $R_s$  and  $Sc_2$ ; tip of  $Sc_1$ ; stigma; anterior cord;  $m-cu$ ; fork of  $M_{1+2}$  and over the supernumerary crossvein in cell  $R_4$ ; other brown clouds in outer radial field, bordering the whitish hyaline marginal spots; veins brown, a little darker in the patterned areas, the veins in the prearcular and basal costal fields paler. Venation:  $Sc_1$  ending about opposite midlength of  $R_s$ ,  $Sc_2$  opposite origin of  $R_s$ ; vein  $R_3$  oblique; supernumerary crossvein at near midlength of vein  $R_4$  in cell  $R_4$ ; cell 2nd  $M_2$  about twice its petiole;  $m-cu$  from about two and one-half to three times its length before the fork of  $M$ ; arcular crossvein and interanal crossvein in transverse alignment near base of wing.

Abdomen dark brown, sparsely pruinose, the lateral and posterior borders of tergites very narrowly and indistinctly paler, the sternites more uniformly darkened. Male hypopygium (Fig. 28) with the outer lobe of basistyle,  $b$ , elongate, pale, enlarged toward tip, provided with numerous setae. Both dististyles longer than this lobe, the outer,  $od$ , unequally bilobed; inner style,  $id$ , bent beyond base, thence expanded into a narrow blade, about the apical third more narrowed into a spine, the tip acute. Aedeagus,  $a$ , flattened, the upper margin with a row of scattered pale setae, the tip narrow.

*Holotype*, ♂, Leeds, June 27, 1945 (G. F. Knowlton). *Allotype*, ♀, pinned with type. *Paratopotypes*, 16 ♂♀; *paratypes*, 4 ♀♀, Washington, June 27, 1945 (G. F. Knowlton); 1 ♀, Springdale, June 28, 1945 (G. F. Knowlton).

I take very great pleasure in naming this unusually interesting fly for my long-time friend and colleague, Professor George F. Knowlton. The species is closest to *Gonomyia* (*Euptilostena*) *dampfiana* Alexander, 1938, of extreme southwestern Mexico, differing in slight details of wing pattern and structure of the male hypopygium. The regional *G. (E.) polingi* Alexander, 1946, is more distantly allied, being readily distinguished by the series of supernumerary crossveins in the costal cell of the wing.

*Gonomyia (Idiocera) blanda* (Osten Sacken, 1859).—Bear Lake, June 30, 1942, several along a small stream; Morgan, July 24, 1945 (K).

*Gonomyia (Idiocera) coloradica* Alexander, 1920.—Logan, July 28, 1939 (K & Nye); Zion National Park, 4,500 ft., June 21-23, 1942; one of the commonest species at and near the Weeping Rock.

*Gonomyia (Idiocera) multistylata* sp. nov.—Belongs to the *blanda* group; general coloration dark gray, conspicuously patterned with yellow, especially on the thoracic pleura; wings narrow, heavily patterned with dark brown;  $Sc$  relatively long,  $Sc_1$  ending beyond midlength of  $R_s$ ;  $m-cu$  about twice its length before the fork of  $M$ ; male hypopygium with four distinct dististyles or branches thereof, the innermost a flattened yellow blade.

♂. Length, about 5.5 mm.; wing, 5.7-5.8 mm.

Rostrum light yellow above, black on sides; palpi black. Antennae with the scape yellow, faintly darkened on lower face; pedicel brown, flagellum black; flagellar segments long-oval to subfusiform, the verticils about equal in length

to the segments. Head yellow, with a conspicuous brownish black area on the posterior vertex.

Pronotum light yellow on sides, more brownish gray medially above; pretergites light yellow. Mesonotal praescutum dark gray, with still darker intermediate stripes; humeral region restrictedly pale yellow; scutal lobes dark gray, each with a dark brown median dash; central portion of scutum with a dark central vitta; posterior lateral portion of each scutal lobe yellow; scutellum dark brown, with a small but conspicuous yellow central spot, parascutella chiefly dark; mediotergite black, sparsely pruinose, each anterior lateral angle light yellow, marking the posterior end of a pale pleural stripe. Pleura and pleurotergite dark gray, conspicuously striped longitudinally with pale yellow; dorsal stripe including the dorsopleural region, continued backward beneath the wing root, including the dorsal pteropleurite and pleurotergite, to the mediotergite, as described; ventral yellow stripe beginning on the fore coxae, crossing the dorsal sternopleurite and ventral mesepimeron onto the metapleura. Halteres with stem yellow, knob black. Legs with the fore and middle coxae chiefly yellow; posterior coxae blackened except at apices; trochanters obscure yellow; femora and tibiae yellow, the tips very narrowly and indistinctly infuscated; basitarsi pale brown, the tips and remainder of tarsi black. Wings (Fig. 30) narrow; ground color whitish subhyaline, the prearcular and costal fields a little more yellowed; a conspicuous dark brown pattern, including spots at *h*, arculus, origin of *Rs*, fork of *Sc*, stigma, over tips of veins  $R_{1+2}$  and  $R_3$ , along cord and over fork of  $M_{1+2}$ ; outer radial field, especially in cell  $R_3$  and tip of 2nd *A* similarly darkened; narrower and less evident markings along veins  $R_5$ , *Cu* and 2nd *A*; two or three small to scarcely evident dark dots in cell *C*; veins dark brown, paler in the brightened costal and prearcular fields. Venation: *Sc* long,  $Sc_1$  ending beyond midlength of *Rs*,  $Sc_2$  near its tip; *Rs* square and slightly spurred at origin;  $R_{1+2}$  and  $R_3$  in punctiform contact at margin, closing cell  $R_1$ ; cell 2nd  $M_2$  subequal in length to its petiole; *m-cu* about twice its length before the fork of *M*.

Abdominal tergites dark brown, the lateral and posterior borders narrowly yellow; sternites somewhat paler brown, the pale caudal borders more diffuse, the sublateral portions of the segments darker; male hypopygium chiefly dark, the apical lobe of basistyle abruptly pale. Male hypopygium (Fig. 33) with the basistyle, *b*, stout, the outer lobe conspicuous, stout, obtuse at apex. Four distinct dististyles, *d*, or profound branches of the same, as shown (in main figure, the inner or fourth style, *id*, is not shown, to avoid confusion); longest style a strong curved rod, black on outer half, the apex obliquely truncated; second style a short slender black spine, gradually narrowed to an acute point; third style intermediate in length between the preceding two, blackened and expanded at the bispinous apex, the short outer or axial spine much smaller than the apical one which bends at a right angle to the axis of the style, both spines acute; fourth or inner style, *id*, a flattened yellow blade, narrow at base, widely expanded outwardly, the apex truncated; surface provided with several setae, their position and relative size about as shown in the figure. Aedeagus, *a*, stout, narrowed to the small apical orifice; surface with numerous scattered setae.

*Holotype*, ♂, Zion National Park, Weeping Rock, 4,500 ft., July 19, 1943 (G. F. Knowlton & P. E. Telford). *Paratypes*, 1 fragmentary ♂, Moab, along stream, 4,000 ft., June 13, 1945 (G. F. Knowlton); 1 ♂, August 21, 1942 (G. F. Knowlton & W. E. Peay).

*Gonomyia (Idiocera) multistylata* is quite distinct from all other Nearctic species of the subgenus, especially in the structure of the male hypopygium. The unusual number of dististyles or profound branches of the same readily separates the species from other somewhat similar forms. Within the limits of this subgenus we find the normal number of three dististyles, but some species (as *blanda*) show only two such styles while a very few others, including the present fly have four, the maximum as known being five, found in *G. (I.) pruinosa* Alexander, of Formosa.

*Gonomyia (Idiocera) proserpina* Alexander, 1943.—Beaver, 7,000 ft., June 27, 1942; found in a wet springy area, the pools with white *Batrachium* and similar more terrestrial yellow *Ranunculus* sp.; *Equisetum arvense* and *E. hiemale*; area slightly shaded by Colorado blue spruce and willows.

*Gonomyia (Idiocera) shannoni* Alexander, 1926.—Settlement Canyon, June 18, 1943 (K).

*Gonomyia (Lipophleps) cinerea* (Doane, 1900).—Moab, along Colorado River, at car lights, September 15, 1943 (K); Zion National Park, Weeping Rock, June 28, 1945 (K).

*Gonomyia (Gonomyia) bihamata* Alexander, 1943.—Beaver, 8,000 ft., June 26-27, 1942.

*Gonomyia (Gonomyia) flicauda* Alexander, 1916.—Eden, June 29, 1943 (K); Mt. Timpanogos, Salamander Lake, August 26, 1943 (K & Maddock).

*Gonomyia (Gonomyia) flavibasis* Alexander, 1916 (*tuberculata* Alexander, 1925).—Hurricane, September 6, 1943 (K).

*Gonomyia (Gonomyia) harmstoni* sp. nov.—Mesonotal praescutum with three brown stripes, the interspaces obscure; rostrum yellow; antennae black throughout;  $Sc_1$  ending about opposite one-fourth to one-fifth the length of  $R_s$ ; male hypopygium with the outer dististyle unusually small; inner style with its outer lobe a simple arcuated black rod; phallosome a pale flattened blade, the apex obtusely rounded.

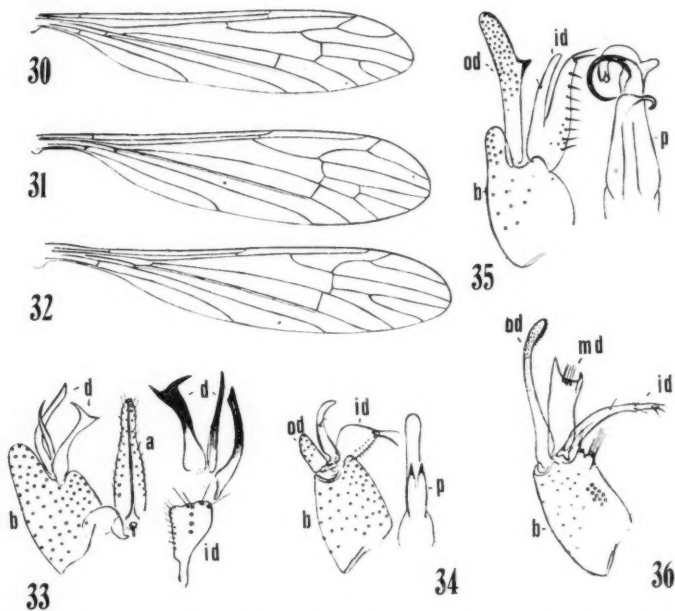
♂. Length, about 4.4-5 mm.; wing, 5.1-6 mm.

Rostrum yellow; palpi black. Antennae black throughout; basal flagellar segments stout, the outer ones more slender. Head light yellow, the center of vertex restrictedly darkened.

Pronotum and pretergites light yellow. Mesonotal praescutum with three brown stripes, the interspaces obscure yellow, the lateral praescutal borders and humeral region broadly light yellow; scutal lobes chiefly dark brown, the surface sparsely pruinose; central region of scutum and base of scutellum restrictedly darkened; mediotergite yellow. Pleura light yellow, patterned with brown, including a longer more dorsal stripe extending from the cervical region across the anepisternum, not involving the pteropleurite; ventral portion of sternopleurite similarly darkened. Halteres elongate, stem pale yellow, knob weakly

infuscated. Legs with coxae and trochanters yellow; femora obscure yellow, clearer basally, the tips passing into brown; tibiae light brown, the tips darker; tarsi passing into brownish black. Wings (Fig. 31) with a weak grayish tinge, the prearcular and costal fields light yellow; stigma barely indicated; veins brown, yellow in the more flavous portions. Venation:  $Sc_1$  ending about opposite one-fourth to one-fifth the length of  $R_1$ ,  $Sc_2$  a short distance from its tip;  $m-cu$  close to the fork of  $M$ .

Abdominal tergites dark brown, the lateral and posterior borders of the segments narrowly light yellow; sternites yellow; hypopygium medium brown on basistyles, the remainder, excepting the lobe of the inner dististyle, more yellowed. Male hypopygium (Fig. 34) with the outer dististyle, *od*, unusually small, only about two-thirds as long as the outer lobe of the inner style, provided with about 12 to 14 setae. Inner dististyle, *id*, with its outer lobe a simple



Figs. 30-36. 30. *Gonomyia (Idiocera) multistylata* sp. n., venation; 31. *Gonomyia (Gonomyia) harmstoni* sp. n., venation; 32. *Gonomyia (Gonomyia) paiuta* sp. n., venation; 33. *Gonomyia (Idiocera) multistylata* sp. n., male hypopygium; 34. *Gonomyia (Gonomyia) harmstoni* sp. n., male hypopygium; 35. *Gonomyia (Gonomyia) paiuta* sp. n., male hypopygium; 36. *Gonomyia (Gonomyia) sevierensis* sp. n., male hypopygium.

(Symbols: *a*, aedeagus; *b*, basistyle; *d*, dististyle; *id*, inner dististyle; *md*, intermediate dististyle; *od*, outer dististyle; *p*, phallosome).

arcuated blackened rod, with a single powerful seta on face beyond midlength; inner lobe appearing as a flattened blade, narrowed to the apex which bears two slightly unequal fasciculate setae; normal setae in rows along lower edge of style. Phallosome, *p*, a flattened pale blade, the apex obtusely rounded; apophyses small, appearing as appressed stout darkened spinous points.

*Holotype*, ♂, Bear Lake, 6,000 ft., June 30, 1942 (*C. P. Alexander*). *Paratopotypes*, 3 ♂♂; *paratypes* 2 ♂♂, Heber, 5,600 ft., August 30, 1943 (*G. F. Knowlton*); 1 ♂, Fish Haven, Idaho, July 24, 1943 (*G. F. Knowlton*).

This interesting fly is named for Mr. Fred C. Harmston, whose cooperation with Professor Knowlton in this study, is greatly appreciated. The fly is readily told from other regional members of the subgenus by the structure of the male hypopygium, especially the dististyles and phallosome. The various allied species in the Rocky Mountain and Great Basin regions fall in the following four groups that are based on the conformation of the apex of the male aedeagus.

1. Apex of aedeagus greatly expanded beyond the apophyses, the outline irregular, before the expanded blade with a more or less developed spine or point.  
*extensivena* Alexander, 1943; *bihamata* Alexander, 1943; *subcinerea* (Osten Sacken, 1859); *vafra* Alexander, 1945.
2. Apex of aedeagus unequally bilobed by a deep apical split.  
*flicauda* Alexander.
3. Apex of aedeagus narrowed to a simple point.  
*poliocephala* Alexander, 1924; *triformis* Alexander, 1946.
4. Apex of aedeagus a simple obtusely rounded blade.  
*harmstoni* sp. nov.

**Gonomya (Gonomyia) paiuta** sp. nov.—Allied to *flavibasis* and *spini-fer*; wings with a weak brownish tinge, stigma oval, pale brown; *Sc* short, *Sc*<sub>1</sub> ending a distance before origin of *R*<sub>s</sub> nearly equal to the length of the latter; cell *M*<sub>2</sub> open by the atrophy of the basal section of *M*<sub>3</sub>; male hypopygium with the outer dististyle fleshy and bulbous on outer portion, the margin beyond midlength produced into a blackened tooth; inner dististyle entirely pale, profoundly divided into two blades, the outer one narrow, cultriform, bearing a single seta; phallosome with the apex pale, obtuse; a conspicuous lateral lobe or tubercule opposite the outer spine.

♂. Length about 4.2-4.5 mm.; wing, 4.5-5 mm.

♀. Length, about 4.5 mm.; wing, 4.5 mm.

Rostrum and palpi black. Antennae with scape and pedicel light yellow, flagellum black; flagellar segments long-oval. Head above yellow, the center of vertex restrictedly infuscated.

Pronotum above light yellow. Mesonotal praescutum with three grayish brown stripes, the lateral margins and restricted interspaces more reddish yellow; pseudosutural foveae reddish chestnut; scutal lobes weakly infuscated; posterior sclerites of notum yellow, the posterior border of mediotergite darkened. Pleura and pleurotergite yellow, traversed by a narrow but conspicuous brown longitudinal stripe extending from the cervical sclerites across the dorsal pleurites to the mediotergite, as described; in cases, the ventral sternopleurite more weakly darkened, the two stripes enclosing a more whitish pleural area. from apex; lower lobe stouter, the two fasciculate setae at apex, back from

Halteres with stem yellow, knob weakly infuscated. Legs with the coxae and trochanters reddish yellow; femora yellow, the tips vaguely darker; tibiae and tarsi brownish yellow, the terminal tarsal segments more infuscated. Wings (Fig. 32) with a weak brownish tinge, the prearcular and costal fields more whitened; stigma oval, pale brown; veins brown. Venation:  $Sc$  short,  $Sc_1$  ending a distance before origin of  $R_s$  that in cases is nearly equal to the length of the latter, in other specimens about two-thirds as long;  $Sc_2$  a short distance from tip of  $Sc_1$ ; vein  $R_3$  oblique; basal section of vein  $R_5$  short to lacking; cell  $M_2$  open by atrophy of basal section of  $M_3$ ;  $m-cu$  a short distance before fork of  $M$ .

Abdominal tergites brown, the caudal borders and lateral angles light yellow; sternites and hypopygium chiefly yellow. Male hypopygium (Fig. 35) of the general types of *flavibasis*, *spinifer* and others, differing in important regards. Apical lobe of basistyle,  $b$ , small and fleshy, the setae on one face. Outer dististyle,  $od$ , a long pale blade that juts beyond the other elements of the hypopygium, the surface with abundant long setae, apex obtuse; inner margin beyond midlength with a conspicuous blackened tooth, not as slender and spinelike as in *spinifer* but more pointed than in *flavibasis*. Inner dististyle,  $id$ , entirely pale, profoundly split into two blades of nearly equal length, the outer narrower and more cultriform, bearing a single seta some distance back from apex; lower lobe stouter, the two fasciculate setae at apex, back from tip on lower margin with a series of more than a dozen strong setae. Phallosome,  $p$ , with the tip obtuse, pale; outer apophysis a strongly curved blackened hook, opposite its base with a conspicuous knob or tubercle; more basal spine weak and not heavily blackened.

*Holotype*, ♂, Weeping Rock, Zion National Park, 4,500 ft., June 21, 1942 (C. P. Alexander). *Allotopotype*, ♀, pinned with type. *Paratopotypes*, numerous ♂♀, June 21-23, 1942 (C. P. & M. M. Alexander).

The specific name is that of the dominant Amerind tribe of this general region. The fly is most similar to species such as *Gonomyia* (*Gonomyia*) *flavibasis* Alexander and *G. (G.) spinifer* Alexander, differing especially in the structure of the male hypopygium, as above discussed. It should be noted that in *spinifer*, together with the closely allied Mexican species *G. (G.) remota* Alexander, 1926, and *G. (G.) subremota* Alexander, 1938, the apex of the aedeagus is produced into a slender blackened spine. The Mexican *G. (G.) expansa* Alexander, 1938, likewise has the male hypopygium much as in the present fly but has the wings with cell  $1st\ M_2$  closed.

*Gonomyia* (*Gonomyia*) *sevierensis* sp. nov.—Belongs to the *noveboracensis* group; wings narrow, with a weak dusky tinge; stigma and a vague seam over the anterior cord slightly more darkened;  $Sc$  short,  $Sc_1$  ending a distance before  $R_s$  about equal to two-thirds to three-fourths the length of the latter; cell  $M_2$  closed; male hypopygium with the outer dististyle long and slender, the slightly dilated apex blackened, the ventral margin with about a dozen erect blackened teeth; intermediate style a broadly flattened pale blade, the outer angle produced into an acute point, the inner angle a small flange, the



apex between these points with from three to five pale setae; inner dististyle unusually slender, not produced into a spine at apex.

♂. Length, about 4.4-5 mm.; wing, 5.4-6 mm.

♀. Length, about 5.5-6 mm.; wing, 6-6.5 mm.

Rostrum obscure yellow above, darker on sides; palpi black. Antennae black throughout; flagellar segments long-oval, the outer ones becoming more slender; verticils exceeding the segments in length. Head above gray, the vertical tubercle and occiput orange.

Pronotum light yellow, narrowly infuscated medially; pretergites and dorso-pleural region light yellow. Mesonotal praescutum and scutum dark brownish gray, without distinct pattern; tuberculate pits and pseudosutural foveae black; scutellum obscure orange behind, more pruinose at base; postnotum chiefly gray, the cephalic lateral portion of mediotergite and anapleurotergite yellow. Pleura conspicuously striped with dark brown on a yellow ground, the more dorsal stripe extending from the cervical region to below the wing root; lower stripe best indicated on the ventral sternopleurite, less evident on the meron. Halteres with stem yellow, knob dark brown. Legs with the coxae and trochanters yellow; remainder of legs chiefly dark brown, the femoral bases restrictedly yellow. Wings narrow, with a weak dusky tinge, the prearcular and costal fields somewhat more yellowed; stigma and a vague seam over the anterior cord slightly more darkened; veins brown, more yellowed in the brightened fields. Venation:  $Sc$  short,  $Sc_1$  ending a distance before  $Rs$  about equal to two-thirds or three-fourths the length of the latter,  $Sc_2$  at its extreme tip;  $Rs$  a little shorter than  $R_{2+3+4}$ , the latter subequal to vein  $R_4$ ; vein  $R_3$  oblique, the distance on costa between  $R_{1+2}$  and  $R_3$  variable, in cases subequal in length to vein  $R_3$ , in other specimens much shorter; basal section of  $R_5$  short;  $m-cu$  at or immediately before the fork of  $M$ .

Abdominal tergites dark brown, the posterior borders yellow, slightly more extensive at the lateral angles; sternites somewhat paler brown, with pale posterior borders; hypopygium obscure yellow. Male hypopygium (Fig. 36) with three dististyles; outer style, *od*, long and slender, the slightly dilated apex blackened, its ventral margin with about a dozen erect black teeth, the most proximal one stouter; outer surface of style for almost the distal half with appressed scabrous points; intermediate style, *md*, a broadly flattened pale blade its outer angle produced into an acute point, the inner angle with a much smaller flange, the concave margin between these points with a group of from three to five long pale setae; inner dististyle, *id*, unusually slender, the tuberculate flange on lower margin before apex small; tip of style not produced into a spine, such as occurs in other species; chaetotaxy of style as figured. Basistyle, *b*, with a rather compact group of about a dozen very long setae on mesal face, these setae only a little shorter than the outer dististyle, the group not as compact as in *percomplexa*. The complex phallosome is not figured.

*Holotype*, ♂, Sevier River, near Hatch, June 23, 1942 (C. P. Alexander). *Allotopotype*, ♀. *Paratopotypes*, several ♂♀.

This fly is readily told from the other western Nearctic members of the group by the details of structure of the male hypopygium, particularly the

dististyles, as indicated in the diagnosis. These relatives include *Gonomyia* (*Gonomyia*) *aciculifera* Alexander, 1919, *G. (G.) tetonensis* Alexander, 1945, and *G. (G.) percomplexa* Alexander, 1946, the last having cell  $M_2$  of the wings open.

*Gonomyia* (*Gonomyia*) *spinifer* Alexander, 1918.—Arches National Monument, September 16, 1943 (*K*); Moab, August 21, 1942 (*K* & *Peay*); Zion National Park, Weeping Rock, May 5, 1943 (*K*).

*Gonomyia* (*Gonomyia*) *subcinerea* (Osten Sacken, 1859) (*obscura* Doane, 1900).—Weber River, June 29, 1943 (*K* & *Telford*).

*Gonomyia* (*Gonomyia*) *triformis* Alexander, 1946.—Beaver, near Beaver Creek, 6,500-7,000 ft., June 27, 1942; Maple Canyon, August 25, 1923 (*Aldous*); University of Utah.

*Gonomyia* (*Gonomyia*) *vafra* Alexander, 1945.—Wolf Creek Pass, Uinta Mts., July 24, 1945 (*K*).

*Rhabdomastix* (*Sacandaga*) *californiensis* Alexander, 1921.—Zion National Park, 4,500 ft., June 21, 1942.

*Rhabdomastix* (*Sacandaga*) *ioogoon* sp. nov.—Allied to *coloradensis*; general coloration light yellow, patterned with brown; head above with a conspicuous central brown stripe; halteres uniformly pale yellow; femora and tibiae yellow, their tips vaguely darker; wings subhyaline, stigma scarcely darker;  $Sc$  relatively short,  $Sc_1$  ending about opposite three-fifths to two-thirds  $R_5$ ; male hypopygium with the outer dististyle darkened, provided with conspicuous appressed spinous points and spinulae, the apical point very short and inconspicuous; blade of gonapophysis relatively narrow, pointed at apex.

♂. Length, about 5.5 mm.; wing, 6.5 mm.

♀. Length, about 6.7 mm.; wing, 7.7.5 mm.

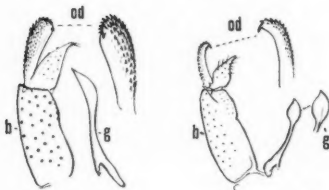
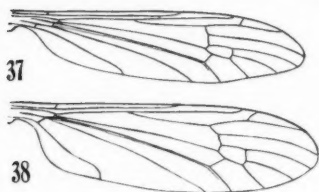
Rostrum yellow, weakly darkened above; palpi brown. Antennae with scape yellow, pedicel and flagellum black; flagellar segments oval, passing into long-oval; longest verticils scarcely equalling the segments, unilaterally distributed. Head above obscure orange, with a conspicuous brownish gray central area that is slightly expanded at near midlength.

Pronotum yellow, slightly darkened laterally. Mesonotal praescutum light yellow, with three broad brownish gray stripes, the wide median one more or less bifid behind, ending far before the suture; lateral stripes crossing the suture onto the scutal lobes; lateral praescutal border paler yellow; pseudo-sutural foveae and tuberculate pits blackened, conspicuous; median region of scutum and base of scutellum brownish gray, the remainder yellow; postnotum yellow, the posterior portion of both mediotergite and pleurotergite more brownish gray. Pleura light yellow, including the dorsopleural membrane, variegated with brownish gray, most conspicuously so on the ventral sclerites, especially the meron. Halteres pale yellow. Legs with the coxae and trochanters yellow; femora and tibiae yellow, vaguely darker at tips; outer tarsal segments dark brown. Wings (Fig. 37) subhyaline, stigma scarcely darker; veins pale brown, more brownish yellow in the prearcular and costal fields. Very sparse

macrotrichia on outer veins from  $R_4$  to  $M_3$ , inclusive. Venation:  $Sc$  moderately long,  $Sc_1$  ending about opposite three-fifths to two-thirds the length of  $R_5$ ,  $Sc_2$  some distance from the tip of  $Sc_1$ , the latter being about one-third longer than  $m-cu$ ; vein  $R_3$  nearly erect, along costal border separated from  $R_{1+2}$  by a distance subequal to its own length;  $R_{2+3+4}$  and  $R_4$  subequal; veins issuing from cell 1st  $M_2$  only moderately elevated or arched;  $m-cu$  about its own length beyond the fork of  $M$ .

Abdominal tergites grayish brown, sternites more yellowed; hypopygium chiefly brownish yellow. Ovipositor with valves very long and slender. Male hypopygium (Fig. 39) with the outer dististyle,  $od$ , darkened, very conspicuous, provided with appressed spinous points and spinulae, the apical beak

very short and inconspicuous, shorter than several of the subtending spines. Inner dististyle strongly narrowed at outer end, entirely pale. Gonapophysis,  $g$ , pale, the apical blade relatively narrow, only about twice as wide as the stem, pointed at tip.



Figs. 37-40. 37. *Rhabdomastix (Sacandaga) ioogoon* sp. n., venation; 38. *Rhabdomastix (Sacandaga) lipophleps* sp. n., venation; 39. *Rhabdomastix (Sacandaga) ioogoon* sp. n., male hypopygium; 40. *Rhabdomastix (Sacandaga) lipophleps* sp. n., male hypopygium.

(Symbols:  $b$ , basistyle;  $g$ , gonapophysis;  $od$ , outer dististyle).

*Holotype*, ♂, Zion National Park, 4,500 ft., June 21, 1942 (*C. P. Alexander*). *Allotopotype*, ♀. *Paratopotype*, 1 ♀.

The term *ioogoon* is the Paiute Indian name for Zion Canyon, from an arrow quiver, "come out the way you come in". Although generally similar to *Rhabdomastix (Sacandaga) coloradensis* Alexander, 1917, the present fly differs evidently in details of coloration, venation and structure of the male hypopygium, especially the short  $Sc$  and structure of the outer dististyle and gonapophysis.

*Rhabdomastix (Sacandaga) leonardi* Alexander, 1930.—Devils Slide, Weber River, on grassy banks above the slide, June 29, 1943 (*K & Telford*); Henefer, June 29, 1943 (*K*); Hyrum, July 23, 1942 (*K*); Moab, June 13, 1945 (*K*); Provo Canyon, July 26, 1945 (*K*); Salina, July 11, 1943 (*K*); Zion National Park, June 21, 1942 (*K*).

*Rhabdomastix (Sacandaga) lipophleps* sp. nov.—General coloration gray, the mesonotum faintly patterned with pale brown; femora obscure yellow, the tips brown; wings grayish subhyaline, restrictedly patterned with pale

brown; macrotrichia on outer veins;  $Sc_1$  ending about opposite three-fifths the length of  $R_s$ ,  $Sc_2$  lacking;  $m-cu$  oblique; male hypopygium with the gonapophysis terminating in an unusually broad flattened blade.

♂. Length, about 6 mm.; wing, 6.5 mm.

Rostrum light brown; palpi black. Antennae (male) short; scape and pedicel brown, flagellum broken. Head light gray; anterior vertex broad.

Pronotum brownish gray, the lateral margins and pretergites obscure yellow. Mesonotum light gray, the praescutum with four poorly indicated pale brown stripes, the scutal lobes similarly patterned; tuberculate pits dark brown, pseudosutural foveae pale; posterior portions of both mediotergite and pleurotergite darkened. Pleura gray, the ventral portions darker; dorsopleural membrane obscure yellow. Halteres with stem light yellow, knob broken. Legs with the coxae and trochanters yellow, fore coxae a trifle darker; femora obscure yellow, the tips brown, of the tibiae more narrowly and inconspicuously so; outer tarsal segments blackened. Wings (Fig. 38) broad, grayish subhyaline, the base narrowly more whitened; stigma oval, very pale brown; narrow to scarcely evident brown seams along cord and outer end of cell 1st  $M_2$ ; veins brown. Macrotrichia on veins  $R_4$ ,  $R_5$  and distal sections of  $M_{1+2}$  and  $M_3$ , fewer on  $R_{2+3+4}$ ,  $M_4$ ,  $Cu_1$  and 2nd  $A$ . Venation:  $Sc$  long,  $Sc_1$  ending about opposite three-fifths  $R_s$ ,  $Sc_2$  lacking; vein  $R_3$  short, oblique, gently sinuous; vein  $R_{2+3+4}$  a little shorter than  $R_4$ ;  $m$  more than twice the basal section of  $M_3$ ;  $m-cu$  oblique, about two-thirds its length beyond the fork of  $M$ .

Abdominal tergites brown, basal sternites somewhat paler; subterminal segments dark brown to form a conspicuous ring; hypopygium more yellowish brown. Male hypopygium (Fig. 40) with the outer dististyle,  $od$ , relatively narrow, terminating in a strong curved point, the outer face of style with abundant appressed spines and spinulae. Inner dististyle nearly as long, strongly narrowed at apex. Gonapophysis,  $g$ , with the stem slender, at apex dilated into a very broad flattened blade, the apex subapiculate.

*Holotype*, ♂, Zion National Park, 4,500 ft., June 22, 1942 (C. P. Alexander). *Allotype*, ♀, Mt. Nebo, July 25, 1942 (G. F. Knowlton).

In its loss of vein  $Sc_2$  of the wings, the present fly agrees more nearly with members of the *lurida* group, including the regional *Rhabdomastix* (*Sacandaga*) *sublurida* Alexander, 1943. However, from the venation and structure of the gonapophyses, it is evidently more nearly allied to species such as *R. (S.) fasciger* Alexander, 1920, all of which have vein  $Sc_2$  strongly preserved. The allotype specimen was added to the type series after the description was prepared. In this, vein  $Sc_2$  is vaguely preserved and it is possible that this specimen may not be conspecific with the type.

*Cryptolabis* (*Cryptolabis*) *molophiloides* Alexander, 1943.—Hayden, July 25, 1945 (K); Vernal, June 27, 1943 (K).

*Cryptolabis* (*Cryptolabis*) *pachyphallus* Alexander, 1943.—Logan, at light, August 3, 1938 (K & Hardy).

*Cryptolabis* (*Cryptolabis*) *sica* Alexander, 1946.—Zion National Park,

Weeping Rock, 4,500 ft., June 21-23, 1942, part of type series; same station, June 28, 1945 (K).

*Ormosia (Rhypholophus) bifdaria* Alexander, 1919.—Beaver, 8,000 ft., June 25-26, 1942; Cedar Breaks, 10,000 ft., June 25, 1942 (M. M. Alexander), June 24, 1942 (Degener & Peiler); Coal Creek Canyon, 9,000 ft., June 25, 1942; Mt. Timpanogos, Aspen Grove (Hardy), July 26, 1945 (K).

*Ormosia (Rhypholophus) wasatchensis* sp. nov.—General coloration brownish gray, the praescutum with the humeral region and interspaces reddish yellow; antennae with the scape and pedicel obscure yellow, flagellum black; knobs of halteres weakly darkened; male hypopygium with the plates of the gonapophyses suboval in outline, the inner apical angle produced into a blackened tail-like extension, the outer angle evenly rounded, unarmed; arms of aedeagus relatively long, subequal in length to the extensions of the gonapophyses.

♂. Length, about 5.5 mm.; wing, 6.6 mm.

♀. Length, about 6 mm.; wing, 6.5 mm.

Rostrum obscure yellow; palpi black. Antennae with the scape and pedicel obscure yellow, flagellum black, the base of the first segment restrictedly pale; flagellar segments elongate-oval to elongate; longest verticils unilaterally distributed. Head light gray; anterior vertex broad.

Pronotum yellow middorsally, more brownish gray on sides; pretergites yellow. Mesonotal praescutum with the humeral region and restricted interspaces reddish yellow, the remainder almost covered by three broad brownish gray stripes, obliterating the interspaces at the suture; posterior sclerites of notum brownish gray, the scutellum a trifle brightened; pleurotergite and lateral borders of mediotergite obscure yellow. Pleura chiefly yellow, sparsely gray pruinose. Halteres with stem yellow, knob rather weakly darkened. Legs with coxae and trochanters yellow; femora obscure yellow, brighter at base, narrowly more darkened at tip; tibiae brownish yellow, the tips narrowly infuscated; tarsi black, the basitarsi paler at proximal ends. Wings (Fig. 41) relatively narrow, strongly tinged with brown, the prearcular and costal fields more yellowed; stigma long-oval, brown; very vague darkenings along cord and outer end of cell 1st  $M_2$ , best evidenced by a slight deepening in color of the veins; veins brown, yellowish in the brightened fields and basal portion of Cu. Venation:  $R_2$  close to fork of  $R_{3+4}$ ; cell 1st  $M_2$  closed, a little longer than vein  $M_4$  beyond it;  $m-cu$  just beyond the fork of  $M$ ; vein 2nd  $A$  unusually sinuous.

Abdominal tergites dark brown, basal sternites clear yellow, the outer ones and the hypopygium a little darker, more brownish yellow. Male hypopygium (Fig. 44) with the inner dististyle relatively narrow. Gonapophysis, g, with the plates suboval in outline, the inner apical angle produced into a blackened tail-like extension, the tip subacute; outer apical angle evenly rounded, unarmed. Arms of the aedeagus, a, relatively long, subequal in length to the extension of the gonapophysis.

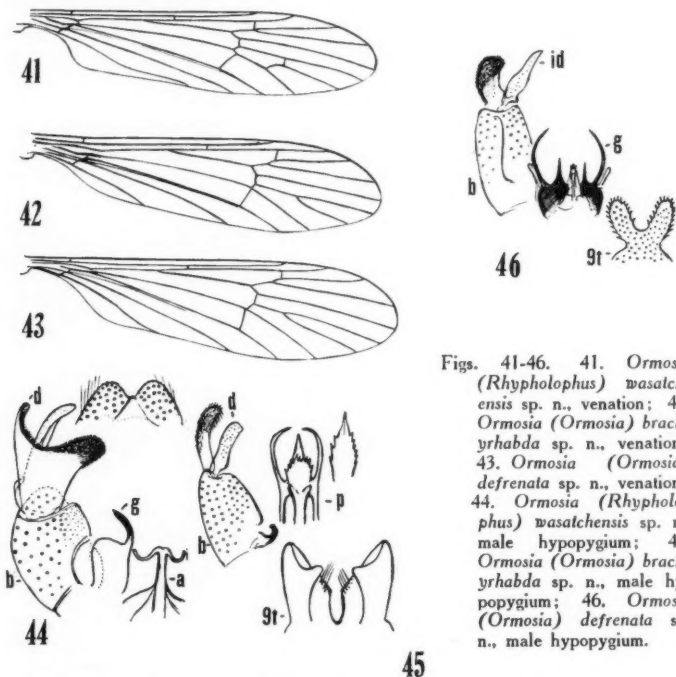
*Holotype*, ♂, Timpooneke Ranger Station, Mt. Timpanogos, August 26, 1943 (G. F. Knowlton & Darrell R. Maddock). *Allotopotype*, ♀. *Paratopo-*

types, 7 ♂♂, 1 pinned with type; paratypes, 1 ♂, 1 ♀, Delta, August 25, 1943 (G. F. Knowlton).

The nearest relative of the present fly is *Ormosia (Rhypholophus) suffumata* Alexander, 1943. It is best distinguished by the structure of the gonapophyses of the male hypopygium, particularly the unarmed outer apical angles. In *suffumata*, these latter are produced into a conspicuous acute spine to make the entire structure bispinous.

*Ormosia (Ormosia) albertensis* Alexander, 1933.—Beaver, 8,000 ft., June 25-26, 1942.

*Ormosia (Ormosia) brachyrhabda* sp. nov.—Allied to *manicata*; general coloration of thoracic notum medium brown, without distinct pattern; male hypopygium with the phallosome consisting of two depressed-flattened central plates that are coarsely serrate on their margins, the longer one extended into a strong central spine; lateral border of the shorter plate produced caudad into a slender blade that extends to a short distance beyond the central spine, the tips of these blades incurved.



Figs. 41-46. 41. *Ormosia (Rhypholophus) wasatchensis* sp. n., venation; 42. *Ormosia (Ormosia) brachyrhabda* sp. n., venation; 43. *Ormosia (Ormosia) defrenata* sp. n., venation; 44. *Ormosia (Rhypholophus) wasatchensis* sp. n., male hypopygium; 45. *Ormosia (Ormosia) brachyrhabda* sp. n., male hypopygium; 46. *Ormosia (Ormosia) defrenata* sp. n., male hypopygium.

(Symbols: a, aedeagus; b, basistyle; d, dististyles; g, gonapophysis; id, inner dististyle; p, phallosome; t, tergite).

♂. Length, about 4.5 mm.; wing, 4.5 mm.; antenna, about 0.5 mm.

Rostrum brown; palpi darker brown. Antennae short, brown throughout; flagellar segments oval to long-oval, with conspicuous verticils. Head brown.

Thorax above medium brown, without distinct pattern, the lateral praescutal borders yellow. Pleura and pleurotergite paler, more yellowish brown. Halteres with stem yellow, knob infuscated. Legs with the coxae and trochanters testaceous yellow; remainder of legs obscure yellow or brownish yellow, femoral tips very weakly more darkened, outer tarsal segments dark brown. Wings (Fig. 42) whitish subhyaline, the prearcular and costal fields a trifle more yellowed; veins pale brown, more yellowed in the brighter portions. Venation: Anal veins divergent; cell 2nd *A* relatively narrow.

Abdominal tergites and hypopygium brown, sternites more yellowed. Male hypopygium (Fig. 45) with the tergite, 9t, greatly enlarged and deeply notched, as in the group. Dististyles, *d*, much as in *manicata*, the outer style narrow, its outer face densely setuliferous; inner style subequal in length, nearly glabrous. Phallosome, *p*, consisting of two depressed-flattened central plates that are coarsely serrate on their margins, the longer one extended into a strong central spine; lateral borders of the shorter plate produced caudad into a narrow blade that extends to a short distance beyond the central spine, the tips of these blades incurved.

*Holotype*, ♂, Henefer, June 29, 1943 (*G. F. Knowlton*). *Paratypes*, ♂, Weber River, June 29, 1943 (*G. F. Knowlton*); ♂, Bear Lake, 6,000 ft., June 30, 1942 (*C. P. Alexander*); ♂ ♂, Arizona Creek, Teton National Forest, Wyoming, 6,790 ft., July 8, 1941 (*C. P. Alexander*); previously recorded (*Alexander, 1945*) as *manicata*.

While very similar in its general appearance to *Ormosia (Ormosia) manicata* (Doane, 1900), the present fly is quite distinct in certain important structures of the male hypopygium, especially the phallosome. In *manicata*, the gonapophyses are three in number, two appearing as very elongate needle-like spines, the slightly broader third element terminating in a furcula.

*Ormosia (Ormosia) defrenata* sp. nov.—Belongs to the *similis* group; general coloration yellow, the mesonotum more reddish yellow; antennae (male) elongate, shorter than body; flagellar segments strongly narrowed outwardly, giving a nodulose appearance to the organ; legs yellow, the outer tarsal segments infuscated; wings with a weak brownish tinge, stigma a little darker but diffuse; male hypopygium with the tergite very deeply notched, the large lobes with their margins conspicuously fimbriate; inner dististyle a slender pale blade; gonapophysis appearing as a darkened bispinous plate, the outer spine long and slender, its tip pale.

♂. Length, about 4.3-4.5 mm.; wing, 4.6-4.8 mm.; antennae, about 3.5 mm.

Rostrum pale yellow; palpi brownish black. Antennae (male) elongate, as shown by the measurements; basal three segments yellow, succeeding segments chiefly dark brown; flagellar segments with basal portion long-oval, the outer half of each narrowed into a slender glabrous stem; longest verticils shorter than the segments. Head above brownish gray.



Pronotum obscure yellow; pretergites clearer yellow. Mesonotum reddish yellow, sparsely pruinose; sides of praescutum paling to yellow. Pleura and pleurotergite somewhat clearer yellow. Halteres with stem yellow, knob weakly darkened. Legs yellow, the outer tarsal segments infuscated. Wings (Fig. 43) with a weak brownish tinge, the prearcular and costal fields somewhat more yellowish; stigma a little darker, very diffuse; veins brown, paler in the more brightened areas. Macrotrichia of cells abundant and well distributed over virtually the entire wing. Venation:  $R_{2+3}$  and  $R_2$  subequal; cell  $M_2$  open by the atrophy of basal section of  $M_3$ ;  $m-cu$  close to the fork of  $M$ ; vein 2nd  $A$  very gently sinuous on its outer fourth.

Abdominal tergites pale brown; sternites and hypopygium yellow. Male hypopygium (Fig. 46) with the tergite, 9t, very deeply notched, the large lobes flattened, their margins produced into long, conspicuous, fimbriate points; surface of tergite, including lobes, with conspicuous setae; base of notch with restricted pale membrane. Outer dististyle a stout suboval blackened lobe, the outer surface with abundant appressed setae that are arranged in more or less distinct rows, as in the group. Inner dististyle, *id*, a slender pale blade, somewhat longer than the outer dististyle. Phallosome with the chief gonapophysis, *g*, appearing as a flattened black plate, the outer angle produced into a slender black rod, the acute tip pale, slightly incurved; inner angle of plate produced caudad into a powerful straight black spine; mesal edge of plate near base with numerous spinulose points or roughenings; a small slender outer gonapophysis. Aedeagus weakly bifid at apex.

*Holotype*, ♂, Mt. Timpanogos, July 26, 1945 (G. F. Knowlton). *Paratypes*, ♂, Beaver, 8,000 ft., June 25-26, 1942 (C. P. Alexander); one broken ♂, Logan Canyon, Spring Hollow, July 5, 1943 (Darrell R. Maddock); 1 ♂, on slide, Moscow Mt., Idaho, July 25, 1920 (R. C. Shannon).

The most similar species superficially is *Ormosia (Ormosia) cockerelli* (Coquillett, 1901), which closely resembles the present fly in the yellow coloration of the body and elongate antennae of the male, differing in the structure of the male hypopygium. The nearest ally appears to be *O. (O.) pugetensis* Alexander, 1946, which is well distinguished by the structure of the hypopygium.

*Ormosia (Ormosia) fusiformis* (Doane, 1900).—Beaver, 8,000 ft., June 25-26, 1942; Mt. Nebo, Bear Canyon Camp, August 14, 1943 (*K*); Settlement Canyon, June 18, 1943 (*K*); Mt. Timpanogos, July 26, 1945 (*K*).

*Ormosia (Ormosia) opifex* Alexander, 1943.—Cedar Breaks, 10,000 ft., along small mountain stream, June 25, 1942 (*M. M. Alexander*).

*Ormosia (Ormosia) spinifex* Alexander, 1943.—Beaver, 8,000 ft., June 25-26, 1942; swept from Colorado blue spruce near mountain stream.

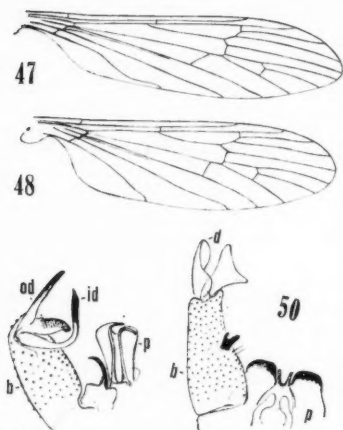
*Ormosia (Ormosia) tetonica* Alexander, 1945.—Mt. Nebo, July 5, 1945 (*Harmston*).

*Erioptera (Psiloconopa) angularis* (Alexander, 1917).—The type was taken near the mouth of Bear River, northern end of Great Salt Lake, September 16, 1914, by Alexander Wetmore. Other records: Circleville, July 9,

1945 (*K*); Howell, August 26, 1942 (*K* & Peay); Junction, June 28, 1945 (*K*); Saltair, May 21, 1926 (*M. C. VanDuzee*); Salt Lake City, May 4, 1945 (*Harmston*).

The species is still poorly known and some further descriptive notes are supplied. Wings (Fig. 47) yellowish gray, slightly paler at base; very small to scarcely evident brown clouds at origin of *Rs*, along cord and over outer end of cell 1st *M*<sub>2</sub>. The venation varies within surprising limits: Cell 1st *M*<sub>2</sub>

may be closed or open by the atrophy of the basal section of vein *M*<sub>3</sub>; *R*<sub>2+3+4</sub>, while usually shorter than *r-m* is, in some specimens, fully three times this length.



Figs. 47-50. 47. *Erioptera (Psiloconopa) angularis* Alexander, venation; 48. *Erioptera (Psiloconopa) hardyi* sp. n., venation; 49. *Erioptera (Psiloconopa) angularis* Alexander, male hypopygium; 50. *Erioptera (Psiloconopa) hardyi* sp. n., male hypopygium.

(Symbols: *b*, basistyle; *d*, dististyles; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome).

Male hypopygium (Fig. 49) with the outer dististyle, *od*, profoundly bifid, both arms blackened, the outer one longer and more slender, its inner edge microscopically crenulate or roughened; inner arm short and broad, its outer face similarly but even more delicately crenulate. Inner dististyle, *id*, a long slender arm, at near midlength bent at a right angle or slightly more, the tip darkened and acute; before apex with a few scattered pale acute spinous points. Gonapophyses appearing as flattened pale basal plates, each produced apically into a slender blackened rod or spine, gently curved, the margin microscopically toothed or crenulate. Phallosome, *p*, appearing as a flattened central plate, at apex produced into two genital tubes.

*Erioptera (Psiloconopa) bispinigera* Alexander, 1930.—Logan Canyon, above Tony Grove, August 12, 1943 (*K* & Maddock).

*Erioptera (Psiloconopa) gaspicola* (Alexander, 1929).—Beaver, 8,000 ft., June 26, 1942.

*Erioptera (Psiloconopa) hardyi* sp. nov.—Allied to *angularis*; general coloration yellow, patterned with darker; antennae with scape yellow, pedicel and flagellum brown; mesonotal praescutum with three light brown stripes, the cephalic portion of the broad central stripe more blackened; halteres yellow, the tips narrowly infuscated; wings broad, grayish subhyaline, with a restricted pale brown pattern; vein 2nd *A* nearly straight, diverging from 1st *A*,

the tip barely sinuous; male hypopygium with a small blackened furcula at near midlength of mesal face of basistyle; inner dististyle blackened, expanded outwardly, the surface smooth; gonapophyses appearing as conspicuous blackened plates or blades, the tips obtuse.

♂. Length, about 5.3-5.5 mm.; wing, 5.4-6 mm.

Rostrum and palpi light yellow. Antennae with scape yellow, pedicel and flagellum brown; basal flagellar segments subglobular to short-oval, the outer four or five becoming smaller. Head above yellow, the center of vertex and occiput more darkened; eyes of male large.

Pronotum and pretergites pale yellow. Mesonotal praescutum with the very restricted interspaces obscure yellow, the disk with three light brown stripes, the surface more or less pruinose; cephalic portion of the broad central stripe more blackened; humeral region and lateral margin light yellow; pseudosutural foveae dark brown; central portion of scutum yellow, crossing the suture onto the praescutum; each scutal lobe with two brownish gray areas, the anterior one larger; scutellum yellow, sparsely pruinose, parascutella a trifle variegated with brown on ventral portion; mediotergite brownish gray, darker on posterior half, the anterolateral portions yellow; pleurotergite yellow, its ventral portion more infuscated. Pleura yellow, conspicuously patterned with brown, especially on anepisternum, ventral sternopleurite and meron. Halteres pale yellow. Legs with the coxae and trochanters yellow; femora yellow; the tips narrowly infuscated, the amount subequal on all legs; tibiae obscure yellow, the tips narrowly brownish black, the bases less evidently darkened; basitarsi yellow, the tips and remainder of tarsi darker. Wings (Fig. 48) broad, grayish subhyaline, with a restricted pale brown pattern, including small spots at origin of  $R_s$  and  $Sc_2$ ;  $R_2$ ; tip of vein  $R_{1+2}$ , and over cord and outer end of cell 1st  $M_2$ ; broad but less distinct dusky washes in outer ends of both Anal cells. Venation:  $Sc_2$  far from tip of  $Sc_1$ , about opposite origin of  $R_s$ , the latter a little shorter than vein  $R_3$ ; cell 1st  $M_2$  closed, a trifle shorter than vein  $M_4$ ;  $m-cu$  about one-fourth to one-half its length before the fork of  $M$ ; vein 2nd  $A$  nearly straight, diverging from vein 1st  $A$ , the tip barely sinuous, the cell broad.

Abdominal tergites obscure yellow, with a vague darker central stripe; sternites and hypopygium clearer yellow. Male hypopygium (Fig. 50) with the basistyle,  $b$ , slender, on mesal face at near midlength with a small blackened furcula, its arms unequal, microscopically scabrous. Outer dististyle a flattened scooplike blade. Inner dististyle larger but not much longer, expanded outwardly, more or less produced into two lobes, their margins blackened, smooth. Phallosome,  $p$ , with the apophyses appearing as conspicuous blackened plates or blades, the tips obtuse or subtruncate.

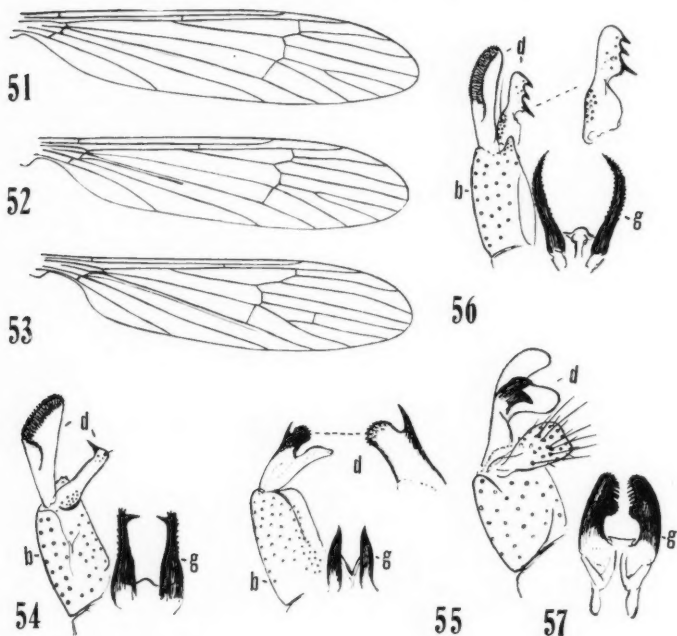
*Holotype*, ♂, Junction, June 28, 1945 (*G. F. Knowlton*). *Paratopotype*, ♂.

I am very pleased to name this distinct fly for Dr. D. Elmo Hardy, who has added most materially to our knowledge of the Diptera of the State. The species differs from *Erioptera (Psiloconopa) angularis* (Alexander, 1917), in the details of coloration of the body and wings and in the venation, in-

cluding the course of vein 2nd *A* and the width of the cell. The male hypopygia are quite different in the two flies (Figs. 49, 50).

*Erioptera (Psiloconopa) lucia* Alexander, 1914.—Huntington Canyon, 5,000 ft., September 1, 1945 (Edmunds & Mulaik), 1 ♂, 1 ♀, cell 1st *M*<sub>2</sub> open by the atrophy of *m* in both specimens; Orangeville, summit of mountains to the west, 10,000 ft., September 6, 1945 (K).

The male hypopygium (Fig. 54) has not been adequately illustrated or described. Outer dististyle widely expanded outwardly. Inner dististyle slender, at apex terminating in a single blackened point that is bent at a right angle to the axis. Gonapophyses, *g*, appearing as blackened rods, just before apex on inner face produced laterad into a strong beaklike spine; surface of apophysis, especially the outer face, with microscopic teeth. The venation varies in



Figs. 51-57. 51. *Erioptera (Psiloconopa) neomexicana* Alexander, venation; 52. *Erioptera (Psiloconopa) telfordi* sp. n., venation; 53. *Erioptera (Psiloconopa) sinawava* sp. n., venation; 54. *Erioptera (Psiloconopa) lucia* Alexander, male hypopygium; 55. *Erioptera (Psiloconopa) neomexicana* Alexander, male hypopygium; 56. *Erioptera (Psiloconopa) peayi* sp. n., male hypopygium; 57. *Erioptera (Psiloconopa) sinawava* sp. n., male hypopygium. (Symbols: *b*, basistyle; *d*, dististyles; *g*, gonapophysis).

the open or closed cell 1st  $M_2$ , as discussed above, both conditions being about equally common.

*Erioptera (Psiloconopa) manitobensis* Alexander, 1929.—Beaver, along Beaver Creek, 6,500 ft., swept from beds of *Equisetum arvense* in river overflow pools, June 27, 1942; Kanab Canyon, May 5, 1943 (K); Provo River, near Utah Lake, July 10, 1945 (K & Telford); Rockville, May 5, 1943 (K).

*Erioptera (Psiloconopa) margarita* Alexander, 1919.—Beaver, 8,000 ft., June 27, 1942, August 12, 1943 (K); Beaver Canyon, 7,200 ft., July 12, 1945 (K & Telford); Beaver Mountain, July 15, 1945 (K); Maple Canyon, June 12, 1943 (K & Telford); Nephi, August 14, 1943 (K & Maddock); Sevier River, at Hatch, June 23, 1942; Zion National Park, Weeping Rock, May 5, 1943 (K), June 21, 1942.

*Erioptera (Psiloconopa) megarhabda* (Alexander, 1943).—Sevier River, near Hatch, June 23, 1942. I formerly considered this as being an *Ormosia* but from the structure of the male hypopygium, the present assignment seems more nearly correct.

*Erioptera (Psiloconopa) microcellula* Alexander, 1914.—Beaver, 7,000 ft., June 27, 1942; Logan Canyon, Lodge Forest Camp, 4,800 ft., June 30, 1942; Monte Cristo Canyon, August 25, 1938 (K & Hardy); Wolf Creek Pass, July 24, 1945 (K).

*Erioptera (Psiloconopa) neomexicana* Alexander, 1929.—Richfield, August 9, 1929 (collector unknown); Salina, July 11, 1943 (K); Zion National Park, Weeping Rock, June 21-22, 1942.

The wing venation is shown (Fig. 51). Male hypopygium (Fig. 55) of distinctive conformation. Basistyle, *b*, not produced apically beyond the bases of the dististyles. Outer dististyle a small blackened blade, at apex rounded and provided with numerous obtuse points or spicules; before apex on outer margin with a conspicuous erect spine. Inner dististyle of approximately the same length, pale or with the apex weakly infuscated; outer portion with numerous weak setae; outer margin before the obtuse tip with a low flange. Gonapophysis, *g*, a simple blackened blade, the tip acute.

*Erioptera (Psiloconopa) peayi* sp. nov.—Allied to *lucia*; general coloration of thorax reddish yellow, the praescutum with a broad grayish brown central stripe that is narrowed behind, not reaching the suture; head gray; halteres pale yellow; femora and tibiae yellow, the tips weakly darkened; wings grayish yellow; cell 1st  $M_2$  closed, small, the second section of vein  $M_{1+2}$  only about one-fourth as long as the outer section; male hypopygium with the inner dististyle terminating in a nearly glabrous blade, the margin produced into three blackened spines, the most basal one largest; gonapophyses long, appearing as strong blackened horns, the surface with abundant blackened spinulae.

♂. Length, about 5 mm.; wing, 5.5 mm.

Rostrum yellow; palpi brownish black. Antennae dark brown throughout; flagellar segments oval, with long verticils. Head gray.

Pronotum and pretergites chiefly very pale yellow. Mesonotum reddish yellow, the praescutum with a broad grayish brown central stripe that is narrowed behind, becoming obsolete before the suture; scutellum more yellowed.

Pleura reddish yellow, unmarked. Halteres pale yellow. Legs with the coxae and trochanters yellow; femora and tibiae yellow, the tips weakly darkened; tarsi passing into brownish black. Wings grayish yellow, the prearcular and costal fields slightly clearer yellow; stigma scarcely indicated; veins brownish yellow to yellow in the brighter fields. Venation: Cell 1st  $M_2$  closed, small, the second section of  $M_{1+2}$  about one-fourth as long as the outer section;  $m-cu$  about one-third its length beyond the fork of  $M$ ; Anal veins divergent, 2nd  $A$  virtually straight.

Abdominal tergites brown, the sternites and hypopygium yellow. Male hypopygium (Fig. 56) with the outer dististyle moderately expanded, with blackened elongate appressed spicules, arranged in about four rows at and back from margin. Inner dististyle elongate, the basal portion with conspicuous pale setae on outer portion, some very long; outer half a more nearly glabrous blade, the margin produced into three blackened spines, the most basal one largest. Gonapophysis,  $g$ , long, blackened, appearing as a strong horn that gradually narrows to the acute tip, its surface with abundant blackened spinulae; apical point in direct longitudinal alignment with the axis, not bent laterad as in *lucia*.

*Holotype*, ♂, Mountains west of Orangeville, Emery Co., near summit, 10,000 ft., September 6, 1945 (G. F. Knowlton). *Paratype*, ♂, Beaver Canyon, 7,200 ft., July 12, 1945 (G. F. Knowlton).

Named for Professor W. E. Peay, who has aided Professor Knowlton in collecting Utah Tipulidae. The most nearly related species include *Erioptera* (*Psiloconopa*) *bispinigera* Alexander, 1930, *E. (P.) lucia*, Alexander, 1914, and *E. (P.) microcellula* Alexander, 1914, all of which differ conspicuously in the structure of the male hypopygium. The single most nearly related species appears to be *lucia*, the hypopygium of which is shown for comparison (Fig. 54).

*Erioptera* (*Psiloconopa*) *sinawava* sp. nov.—Allied to *dorothea*; general coloration brownish gray, the praescutum with four relatively well-defined stripes; antennae (male) moderately long, dark brown throughout; halteres pale yellow; femora obscure yellow, the tips narrowly and weakly darkened; wings yellowish gray, conspicuously patterned with brown and brownish gray, the heaviest pattern being the costal series of markings; cell 1st  $M_2$  unspurred,  $m$  about one-half the basal section of  $M_3$ , vein 2nd  $A$  almost straight; male hypopygium with each gonapophysis a massive structure, the outer half heavily blackened, the mesal face conspicuously toothed.

♂. Length, about 4.5-5 mm.; wing, 5-6 mm.

Rostrum grayish pruinose; palpi black. Antennae relatively long, dark brown throughout; flagellar segments long-cylindrical, with a dense erect white pubescence. Head brownish gray.

Pronotum obscure testaceous yellow. Mesonotum chiefly brownish gray, the praescutum with four relatively well-defined brown stripes, the humeral and lateral portions paling to obscure yellow; pseudosutural foveae extensive, pale reddish, little conspicuous against the ground; tuberculate pits black, lying on a transverse level with the foveae; posterior sclerites vaguely patterned

with obscure yellow, including the posterior portions of the scutal lobes and the caudal border of the scutellum; mediotergite and pleurotergite at the suture extensively yellowed. Pleura obscure yellow or buffy yellow, the ventral sclerites light gray, including the ventral sternopleurite, meron and metapleura. Halteres pale yellow. Legs with the coxae and trochanters light yellow; femora obscure yellow, the tips narrowly and weakly darkened; tibiae obscure yellow, the tips with the tarsi, more infuscated. Wings (Fig. 53) yellowish gray, conspicuously patterned with brown and brownish gray; the darker spots are costal in distribution, arranged as follows: Arculus; origin of  $R_5$ ;  $Sc_{2-3}$ ; cord; tip of  $R_1$ ; marginal clouds at ends of all veins excepting  $R_5$  and  $M_{1-2}$ ; outer end of cell 1st  $M_2$ ; paler and less evident brownish gray washes, especially in the outer radial and anal cells; veins yellow, darkened in the patterned areas. Venation:  $R_5$  shorter than vein  $R_3$ ;  $R_{2+3+4}$  subequal to or longer than  $R_{2+3}$ ; cell 1st  $M_2$  moderately long, unspurred,  $m$  about one-half or less the basal section of  $M_3$ ; Anal veins divergent, 2nd  $A$  almost straight.

Abdomen brown or yellowish brown, more darkened laterally, the caudal borders of the segments narrowly yellow. Male hypopygium (Fig. 57) with the outer dististyle divided into broadly flattened blades, each with the outer margin darkened, the broad lower edge yellow; near notch of the blades with a further blackening that includes a strong spine. Inner dististyle large and fleshy, widened outwardly, provided with numerous setae, some very long. Gonapophysis,  $g$ , appearing as a massive structure, the outer half heavily blackened, the mesal face conspicuously toothed, the outermost denticles very small and appressed, the more basal ones fused into a flangelike mass.

*Holotype*, ♂, Zion National Park, Weeping Rock, 4,500 ft., June 21, 1942 (*C. P. Alexander*). *Paratopotypes*, 1 ♂, with type; 1 ♂, September 7, 1943 (*G. F. Knowlton*).

The specific name, *sinawava*, is that of a god of the Paiute Indians in southern Utah; compare "The Temple of Sinawava", in Zion National Park. Although generally similar to species such as *Erioptera* (*Psiloconopa*) *dorothea* Alexander, 1914, and *E. (P.) zukeli* Alexander, 1940, the present fly is entirely distinct in the structure of the male hypopygium. I had formerly recognized the subgenus *Ilisia* Rondani, 1856, as being sufficiently distinct from *Psiloconopa* Zetterstedt, 1838, but in the light of constant accessions of new species it does not seem advisable to try to maintain the two names as separate groups. Furthermore, *Hoplolabis* Osten Sacken, 1869 is similarly becoming more and more difficult to maintain and will probably have to be placed in the synonymy. As has been pointed out by Bergroth, Edwards, the present writer and others, it is almost impossible to define and keep separate the many groups that have been recognized in the Eriopteraria.

*Erioptera* (*Psiloconopa*) *telfordi* sp. nov.—General coloration yellow, restrictedly patterned with brown, including two narrow lines on the praescutal interspaces; antennae with scape and pedicel yellow, flagellum black; thoracic pleura not or scarcely patterned; femora brownish yellow, very gradually more darkened at tips; wings whitish subhyaline, unpatterned except for the slightly darker stigma; cell  $M_2$  open by the atrophy of basal section of



$M_3$ ;  $m-cu$  at or just before the fork of  $M$ ; Anal veins divergent, 2nd  $A$  straight or evenly convex, the cell relatively narrow; abdominal segments with the posterior borders narrowly yellow.

♀. Length, about 5 mm.; wings, 5.2 mm.

Rostrum and palpi yellow. Antennae with scape and pedicel light yellow, flagellum black; antenna broken beyond the second flagellar segment. Head light yellow in front, darker yellow behind; vertex with a narrow dark brown median vitta.

Pronotum light brownish gray, narrowly light yellow on sides. Mesonotal praescutum light gray, the stripes differentiated only by conspicuous brown interspaces on the posterior half of sclerite, the anterior end of each terminating at the light brown pseudosternal fovea; tuberculate pits black, on a transverse level with the fovea; scutal lobes light gray, the median region more testaceous; along mesal portion of each lobe with a short brown mark that is a direct continuation of the prescutal interspace; posterior portions of scutal lobes clear light yellow; posterior sclerites of notum testaceous yellow, weakly pruinose; mediotergite with cephalic half clearer yellow, the posterior part darkened; pleurotergite yellow. Pleura yellow, sparsely pruinose, unpatterned except for exceedingly vague darkenings on the ventral sternopleurite and meron. Halteres pale yellow. Legs with the coxae and trochanters pale yellow; femora brownish yellow, clearer yellow basally, passing very gradually into brown at the tips; tibiae light brown; tarsi passing into black. Wings (Fig. 52) whitish subhyaline, the stigma a trifle darker, very inconspicuous; no distinct pattern elsewhere on wing; veins pale brown, those in the prearcular and costal fields more yellowed. Venation:  $Sc_1$  ending nearly opposite the fork of  $Rs$ ,  $Sc_2$  far from its tip, about opposite one-sixth the length of  $Rs$ ;  $R_{2+3+4}$  about one-half longer than the basal section of  $R_5$ ; vein  $R_3$  gently sinuous; cell  $M_2$  open by the atrophy of basal section of  $M_3$ ;  $m-cu$  at or shortly before the fork of  $M$ ; Anal veins strictly divergent, vein 2nd  $A$  straight or evenly convex, the cell relatively narrow.

Abdominal tergites yellow, with indications of a darker central stripe, more extensive on the more proximal segments and as a subterminal suffusion; tergites five and six less evidently darkened; posterior borders of tergites conspicuously light yellow; sternites yellow, the posterior margins narrowly paler yellow.

*Holotype*, ♀, Lakota, Bear Lake, July 29, 1945 (G. F. Knowlton).

This species is named for Mr. P. E. Telford, associated with Professor Knowlton in the collection and study of the insect fauna of Utah. The nearest relative seems to be *Erioptera* (*Psiloconopa*) *neomexicana* Alexander, 1929, which differs in the details of coloration of body and appendages. It is believed that the discovery of the male sex will reveal further differences in the hypopygia.

*Erioptera* (*Hoplolabis*) *armata* Osten Sacken, 1859.—Brigham, June 17, 1938 (Hardy & Stains); Eden, June 29, 1943 (K); Henefer, along margins of Weber River, June 29, 1943 (K), August 30, 1943 (K & Telford); Kaneshville, June 12, 1937 (Hardy); Kaysville, June 9, 1938 (K & Hardy); Layton,

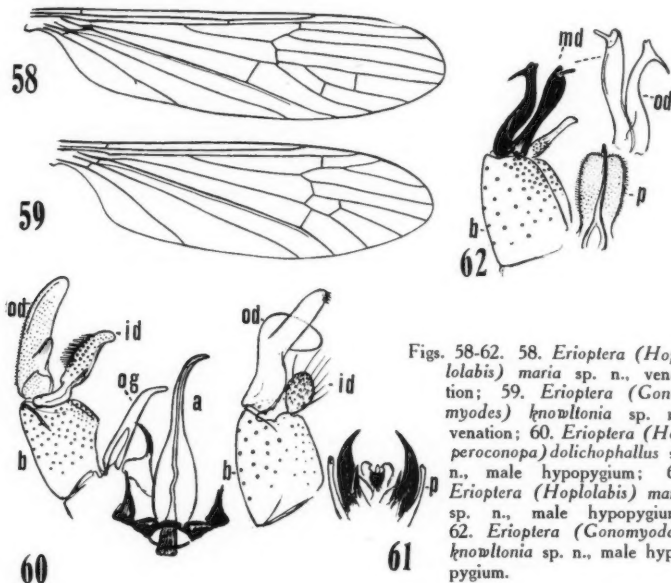
at light, May 25, 1939 (K); Nephi, August 14, 1943 (K & Maddock); Ogden, June 12, 1945 (Harmston); Spanish Fork, May 2, 1936 (Hardy), at light, June 9, 1938 (K).

**Erioptera (Hoplolabis) maria** sp. nov.—Allied to *bipartita*; mesonotal praescutum with the stripes confluent, covering the disk; wings restrictedly patterned with brown, the outer costal areas larger; cell 1st  $M_2$  completely divided by the spur on basal section of  $M_3$ ; male hypopygium with the gonapophyses appearing as black, gently curved smooth horns, the tips acutely pointed, at base of each major apophysis with a small straight black spine.

♂. Length, about 4.5 mm.; wing, 5.5 mm.

Rostrum and palpi brownish black. Antennae with scape light brown, pedicel and basal three or four flagellar segments obscure yellow, the remainder brown; basal flagellar segments oval to long-oval, the outer ones more elongate. Head brownish gray.

Pronotum brownish gray; the posterior portion and the pretergites obscure yellow. Mesonotal praescutum with the disk brownish gray, the three usual stripes being confluent, the humeral and lateral portions obscure yellow; pseudosutural foveae dark reddish brown; scutum brownish gray, with a capillary blackish median vitta; posterior portions of scutal lobes restrictedly



Figs. 58-62. 58. *Erioptera (Hoplolabis) maria* sp. n., venation; 59. *Erioptera (Gonomyodes) knowltonia* sp. n., venation; 60. *Erioptera (Hesperoconopa) dolichophallus* sp. n., male hypopygium; 61. *Erioptera (Hoplolabis) maria* sp. n., male hypopygium; 62. *Erioptera (Gonomyodes) knowltonia* sp. n., male hypopygium.

(Symbols: a, aedeagus; b, basistyle; id, inner dististyle; md, intermediate dististyle; od, outer dististyle; og, outer gonapophysis; p, phallosome).

yellow; scutellum obscure yellow, vaguely more darkened at base; mediotergite brownish gray, the sides broadly yellow. Pleura and pleurotergite almost uniformly medium brown, with faint indications of a paler ventral stripe, most evident on the dorsal sternopleurite and meral region. Halteres with stem yellow, knob brown. Legs with the coxae and trochanters obscure yellow; outer segments passing into brownish black. Wings (Fig. 59) with the ground color grayish yellow, the prearcular region clearer yellow; a conspicuous brown pattern, arranged much as in *bipartita*, including a series of costal darkenings, those at cord, tip of  $R_{1+2}$  and  $R_3$  larger and darker; cord and outer end of cell 1st  $M_2$  darker; smaller brown spots in most parts of wings, including  $h$ , origin of  $Rs$ ,  $Sc_2$ , cell  $C$  above the origin of  $Rs$ , ends of longitudinal veins, and a series of small spots in cell  $Cu_1$ ; elsewhere the veins and membrane more or less streaked longitudinally with paler brown, most evident in the centers of cells  $R$  and 1st  $A$  and as seams along the outer radial veins; veins yellow, darker in the patterned portions. Venation: Much as in *bipartita*; cell 1st  $M_2$  completely divided by the spur from the basal section of  $M_3$ , forming cells 1st  $M_2$ , 2nd  $M_2$  and 3rd  $M_2$ ; a short spur on vein 2nd  $A$  at near two-thirds the length, jutting into cell 2nd  $A$ .

Abdomen chiefly dark brown, subterminal segments and hypopygium a trifle paler. Male hypopygium (Fig. 61) with the outer dististyle, *od*, blackened, divided into two oval lobes, the inner one somewhat broader, the surface microscopically roughened by papillae in broken rows; outer arm at tip with several erect delicate setae. Inner dististyle, *id*, a short-oval pale lobe, provided with numerous setae, the stem glabrous. Phallosome, *p*, with the major apophysis appearing as a black, gently curved smooth horn, the tip acutely pointed; at its base with a small straight blackened spine.

*Holotype*, ♂, Rockville, May 5, 1943 (G. F. Knowlton). *Paratypes*, ♂♀. Beaver Canyon, Puffers Lake, July 20, 1936 (D. Elmo Hardy); Blacksmith Fork Canyon, June 12, 1938 (D. Elmo Hardy); Blanding, June 10, 1939 (collector unknown); Currant Creek, 7,200 ft., June 28, 1943 (G. F. Knowlton); Ferron Reservoir, September 1, 1945 (Edmunds & Mulaik).

This interesting crane-fly is named in honor of Mrs. Mary W. Knowlton, who has collected several interesting species of Tipulidae in Utah. The most similar species is *Erioptera* (*Hoplobasis*) *bipartita* Osten Sacken, 1877, of the Pacific States, which differs in the structure of the male hypopygium, particularly the gonapophyses. It may further be noted that certain species of the subgenus *Psiloconopa*, as *E. (P.) zukeli* Alexander, likewise have the general structure of the hypopygium much the same and serve to break down the supposed distinctions between these two subgenera.

Genus *Erioptera* Meigen; *Hesperoconopa*, subgenus nov.

Antennae short to moderate in length, 16-segmented; flagellar segments oval or with lower face slightly protuberant. Wings with  $Sc_2$  atrophied or very faintly preserved, when present with vein  $Sc_1$  unusually short, subequal to  $r-m$  or less;  $Rs$  long;  $R_{2+3+4}$  in longitudinal alignment with  $R_4$ ,  $R_{2+4}$  perpendicular or subperpendicular at its origin;  $R_{1+2}$  elongate, exceeding  $R_{2+3+4}$ ; inner ends of cells  $R_4$ ,  $R_5$ , 1st  $M_2$  and  $M_4$  in transverse alignment; cell  $M_2$  open by the atrophy of  $m$ ; Anal veins divergent. Male hypopygium

(Fig. 60) with both dististyles apical in position, the outer style bearing a conspicuous lobe or branch on face before midlength; surface of style with abundant microscopic setulae; inner style on outer surface with conspicuous erect or retrorse setae. Two pairs of gonapophyses, the outer pair narrowed to the tips, the inner pair acute or spatulate at apex.

*Type of subgenus*.—*Erioptera* (*Hesperoconopa*) *aperta* (Coquillett, 1905): Western Nearctic Region.

Other included species are *E. (H.) dolichophallus* sp. nov., *E. (H.) melanderi* Alexander, 1944; and *E. (H.) pilipennis* Alexander, 1918.

There can be no question of at least the subgeneric distinctness of the present group, which is well distinguished by the short vein  $Sc_1$  and the basic plan of structure of the male hypopygium. All of the species that I have collected were found close to the margins of mountain streams and the larvae are presumably aquatic or subaquatic.

*Erioptera* (*Hesperoconopa*) *aperta* (Coquillett, 1905) (*mormon* Alexander, 1927).—Bear Lake, near Garden City, June 30, 1942; Logan Canyon, 5,500 ft., June 23, 1926 (J. G. Needham), types of *mormon*; Mt. Timpanogos, July 26, 1945 (K).

*Erioptera* (*Hesperoconopa*) *dolichophallus* sp. nov.—Size small (wing about 4 mm.); general coloration gray, the praescutum with a single blackish stripe; wings without trichia in cells or with these very restricted; male hypopygium with the inner dististyle narrow; inner gonapophysis a slender blackened rod, the tip acute; aedeagus elongate, extending far beyond the gonapophyses, the base conspicuously expanded.

♂. Length, about 3.7-3.8 mm.; wing, 4.4-2 mm.; antenna, about 1-1.1 mm.

♀. Length, about 5 mm.; wing, 4.4-2 mm.

Rostrum and palpi black. Antennae black throughout, moderately long; basal flagellar segments subcylindrical, the outer ones shorter, passing into oval. Head dark gray.

Pronotum brownish gray. Mesonotum plumbeous gray, the praescutum with a single broad blackish median stripe. Pleura gray. Halteres uniformly pale yellow. Legs with the coxae brownish yellow; trochanters clearer yellow; femora obscure yellow on basal third or slightly more, thence passing into brownish black; tibiae and tarsi black. Wings relatively narrow, with a grayish tinge, the stigma very poorly indicated; veins brown, those at base paler. Cells of wings without trichia or with these restricted to one or two scattered setae in the outer cells, especially  $R_3$ , 1st  $A$  and 2nd  $A$ . Venation:  $Sc_1$  ending beyond the fork of  $R_s$ ,  $Sc_2$  a short distance from its tip,  $Sc_1$  alone shorter than  $r-m$ ; cell  $M_2$  open by the atrophy of  $m$ .

Abdomen black, gray pruinose, with conspicuous erect pale setae; hypopygium light brown. Male hypopygium (Fig. 60) with the lateral lobule of the outer dististyle, *od*, relatively slender, broad-based. Inner dististyle, *id*, narrow, the inner margin not produced. Inner gonapophysis appearing as a slender blackened rod that narrows gradually to the acute point, the margin microscop-

ically roughened. Aedeagus, *a*, long, extending far beyond the gonapophyses, the base conspicuously expanded.

*Holotype*, ♂, Green Mountain Falls, Ute Pass, Colorado, 8,000 ft., June 26, 1934 (C. P. Alexander). *Allotopotype*, ♀. *Paratopotypes*, ♂♀; *paratypes*, ♂♀, Beaver, Utah, 8,000 ft., June 26, 1942 (C. P. Alexander); Kents Lake, Beaver Mtn., July 12, 1945 (G. F. Knowlton); North Fork of Provo Canyon, Utah (D. Elmo Hardy).

Readily told from the related species listed above by the structure of the male hypopygium, particularly the pointed inner gonapophyses and the elongate aedeagus.

Genus *Erioptera* Meigen; *Gonomyodes* subgenus nov.

Characters as in *Gonempeda*, differing especially in the details of venation and structure of the male hypopygium. Wings (Fig. 59) with *Sc* long, *Sc*<sub>1</sub> ending beyond fork of *Rs*, *Sc*<sub>2</sub> faint but apparently only a short distance removed from the tip of *Sc*<sub>1</sub>; cell *R*<sub>3</sub> *Gonomyia*-like, large and sprawly, its inner end acute, *R*<sub>2</sub> a little more than one-half *R*<sub>2+3</sub>; *Rs* elongate, subequal in length to the distal section of *R*<sub>5</sub>; cell 1st *M*<sub>2</sub> closed, *m-cu* about one-third its length beyond the fork of *M*; Anal veins divergent. Male hypopygium (Fig. 62) with the basistyle, *b*, not produced at apex; three dististyles, *d*, all terminal in position, the outer two blackened, of peculiar shape, as figured, the outermost at apex produced into a long, slightly retrorse spine; intermediate style at apex produced into a cylindrical blackened peg; inner style only about one-half as long as the others, pale, more or less cultriform at tip, the bases with several long conspicuous setae. No well-defined apophyses unless these are represented by conspicuous hairy phallosomic cushions, *p*, on either side of the slender aedeagus.

Type of subgenus.—*Erioptera* (*Gonomyodes*) *knowltonia* sp. nov.: Western Nearctic Region.

Superficially, the present fly most resembles species of the subgenus *Gonempeda* Alexander, 1924, but from the structure of the male hypopygium it cannot be referred to this group, nor to the other allied subgenera, as *Cheilotrichia* Rossi, 1848, or *Empeda* Osten Sacken, 1869 (*Platytoma* Liroy, 1863).

*Erioptera* (*Gonomyodes*) *knowltonia* sp. nov.—General coloration brownish gray, the praescutum without clearly evident stripes; wings pale grayish, the stigma faintly darker; veins relatively pale and indistinct; *Sc*<sub>2</sub> faint but evident, only a short distance from the tip of *Sc*<sub>1</sub>; cell *R*<sub>3</sub> *Gonomyia*-like, acutely pointed at inner end; cell 1st *M*<sub>2</sub> closed, *m-cu* about one-third its length beyond the fork of *M*; male hypopygium with three dististyles, all terminal in position, the two outer styles blackened and of peculiar and distinctive conformation; phallosomic lobes densely hairy.

♂. Length, about 4.5 mm.; wing, 4.8 mm.

Rostrum brown; palpi darker brown. Antennae dark brown throughout; scape and pedicel large; verticils of flagellum exceeding the segments in length. Head gray.

Pronotum brownish gray; pretergites very pale yellow, conspicuous. Mesonotal praescutum brownish gray, without clearly evident stripes, pseudosutural foveae reddish, relatively large but scarcely evident against the ground; tuberculate pits black, placed about midway between the level of the cephalic praescutal border and the pseudosutural foveae, separated from one another by a distance about equal to their own diameter; posterior sclerites of notum brownish gray, the posterior portion of scutellum a little more testaceous. Pleura brownish gray, entirely without setae. Halteres with stem whitish, knob weakly darkened. Legs with the coxae pale testaceous brown; trochanters yellow; remainder of legs yellow, broken beyond the basitarsi. Wings (Fig. 59) with a pale grayish tinge, the stigma faintly darker; prearcular and costal fields a trifle more yellowed; veins pale, relatively inconspicuous against the ground. Macrotrichia on veins beyond cord and on distal ends of primary veins basad of cord, most nearly lacking on 1st A. Venation: As given under the subgeneric diagnosis.

Abdomen pale brown, the hypopygium more yellowish. Male hypopygium (Fig. 62) as described under the subgenus.

*Holotype*, ♂, Mt. Nebo, August 14, 1943 (G. F. Knowlton & D. R. Maddock).

I take very great pleasure in naming this very distinct fly for my good friend, Professor George F. Knowlton, to whom we owe in greatest part our present satisfactory knowledge of the Tipulidae of Utah. This small obscure fly is of exceptional interest. Superficially it much resembles species of the subgenus *Gonempeda*, such as *Erioptera* (*Gonempeda*) *burra* Alexander, 1924, and *E. (G.) yellowstonensis* Alexander, 1943, but is an entirely distinct type that cannot well be confused with any others in our fauna.

*Erioptera* (*Empedomorpha*) *empedoides* (Alexander, 1916).—Bluff, August 30, 1942 (K & Peay); Green River, April 23, 1943 (K & Wood); Hurricane, September 6, 1943 (K); Moab, August 21, 1942 (K & Peay); Rockville, under willow shade along the Virgin River, May 5, 1943 (K); Spanish Fork, at light, June 9, 1938 (K); Ten Mile, Escalante Desert, June 1936 (Tanner); Woodside, in wet area along margin of Price River, June 14, 1945 (K). A more detailed account of this interesting fly is given elsewhere (Amer. Midl. Nat., 35: 527-529; 1946).

*Erioptera* (*Trimicra*) *pilipes* (Fabricius, 1787).—Benjamin, June 21, 1945 (K & Telford); Bloomington, June 28, 1945 (K); Brigham, August 5, 1943 (K); Callao, August 7, 1945 (K); East Promontory, August 26, 1942 (K); Leeds, August 8, 1942 (K & Peay); Ogden, October 13, 1945 (Harmston); St. George, May 18, 1944, June 28, 1945 (K); Washington, May 18, 1944, June 27-28, 1945 (K).

*Erioptera* (*Symplecta*) *cana* (Walker, 1848) (*hybrida* and *punctipennis* records in earlier literature).—American Fork, June 15, 1937 (Hansen); Avon Canyon, July 24, 1942 (K); Bear Lake, Ideal Beach, July 18, 1945 (K); Bear River City, June 12, 1945 (K); Beaver, May 16, 1945, June 27, 1945 (K), July 11, 1945 (K & Telford); Beaverdam, June 10, 1938 (K), June 16,



1945 (Telford); Benjamin, June 21, 1945 (K & Telford); Benson, June 23, 1945 (K & Nye), July 5, 1943 (K & Telford); Bothwell, June 22, 1938 (D. E. & A. T. Hardy); Brigham, June 24, 1944 (Wood); Brigham Canyon, August 1, 1942 (K); Cache Junction, April 27, 1938 (K & Hardy); Callao, August 7, 1945 (K); Cedar City, May 28, 1938 (K & Sargent); Clarkston, April 8, 1938 (K & Hardy); Corinne, May 24, 1945 (K); Cornish, May 31, 1938 (Hardy); Cove, April 27, 1938 (K & Hardy); Draper, May 10, 1939 (K); Eden, June 4-8, 1938 (K & Hardy); Elberta, June 2, 1938 (Hansen); Fairfield, August 10, 1942 (K & Peay); Fish Springs, August 8, 1945 (K); Gandy, August 8, 1945 (K); Garfield, May 25, 1945 (K); Garland, June 10, 1938 (K & Hardy); Hatch, June 28, 1945 (K), August 9, 1942 (K & Peay); Huntington Canyon, September 1, 1945 (Edmunds); Huntsville, June 14, 1938 (K & Stains); Hurricane, September 7, 1943 (K); Hyde Park, June 4-13, 1938 (Hardy & Stains); Hyrum, June 6, 1938 (Hardy); Junction, June 28, 1945 (K); Kanab Canyon, May 5, 1943 (K); Kanesville, June 16, 1937 (Hardy); Koosharem, July 10, 1943 (K & Telford); Lehi, May 10, 1945 (K); Lewiston, April 7, 1938 (K & Hardy); Liberty, May 21-June 4, 1938 (K & Harmston); Loa, July 3, 1938 (K & Harmston); Logan, April 20-September 26, 1938 (K & Hardy); Logan Canyon, June 30, 1942, July 4, 1945 (K), August 7, 1938 (Hardy); Magna, June 30, 1945 (K); Midway, August 14, 1943 (K & Maddock); Mill Creek Canyon, June 24, 1938 (K & Hardy); Mt. Nebo, August 14, 1943 (K & Maddock); Nibley, July 28, 1938 (K & Harmston); Ogden, April 24, 1943 (K & Maddock), May 25, 1939 (K), June 12, 1945 (Harmston); Payson, April 22, May 8, 1938 (K); Pleasant Grove, June 22, 1937 (K & Hansen); Providence, July 28, 1938 (K & Nye); Richfield, June 28, 1945 (K); Richmond, June 17, 1938 (K & Nye); Roy, June 16, 1945 (K); St. George, May 22, 1919 (collector unknown); Salem, September 18-23, 1943 (K); Salt Lake City, June 10, 1945 (Edmunds & Mulaik), August 21-September 21, 1939 (Rees); Sardine Canyon, May 24, 1938 (Hardy); Scipio, May 31, 1945 (K); Slaterville, June 16, 1945 (K); Spanish Fork, June 8, 1938 (K); August 10-September 21, 1943 (K); Syracuse, June 10, 1938, July 16, 1939 (K); Mt. Timpanogos, July 26, 1945 (K); Tooele, August 22, 1937, on goldenrod (Hansen); Virgin, May 18, 1944 (K); Wellsville, June 14, 1938 (Hardy & Stains), August 10, 1938 (K & Harmston); Wolf Creek Pass, 9,400 ft., July 24, 1945 (K), Woodland, July 24, 1945 (K); Woodruff, July 24, 1943 (K & Maddock); Zion National Park, near Zion Lodge, May 5, 1943 (K).

*Erioptera (Erioptera) septemtrionis* Osten Sacken, 1859.— American Fork Canyon, July 26, 1945 (K); Bear Lake, Ideal Beach, August 13, 1939 (K & Harmston); Brigham, June 17, 1938 (Hardy & Stains); Eden, August 30, 1943 (K & Telford); Ephraim Canyon, near summit, September 6, 1945 (K); Garden City, August 10, 1939 (K & Harmston), August 21, 1942 (K, Roberts & Wood); Hayden, May 23, 1945 (K & Harmston); Heber, August 14, 1935 (K & Maddock); Honeyville, June 16, 1945 (K); Huntsville, August 21, 1942 (K, Roberts & Wood); Little Valley, near Vernon Creek, June 18, 1943 (K); Logan, at light, August 3-September 30, 1938 (K, Hardy & Nye); Logan Canyon, June 18, 1945 (K), June 30, 1942; Medon,



August 1, 1942 (K); Midway, August 14, 1943 (K & Maddock); Oakley, August 15, 1943 (K & Maddock); Ogden, June 12, 1945 (Harmston); Provo (Hardy); Soldiers Summit, September 16, 1943 (K); Mt. Timpanogos, Glacier Lake (Hardy); Wolf Creek Pass, near summit, July 24, 1945 (K); Woodland, July 24, 1945 (K).

*Erioptera (Erioptera) villosa* Osten Sacken, 1859 (*dilatata* Alexander, 1924).—Bear Lake, near Ideal Beach, July 18, 1945 (K); Beaver, July 11, 1945 (K & Telford); Kamar, July 24, 1945 (K); Laketown, July 12, 1938 (K & Harmston); Lakota, at meadow edge, July 24, 1943 (K & Maddock); Logan Canyon, June 9, 1943 (Maddock); Peoa, July 24, 1945 (K); Providence, July 2, 1943 (Telford); Provo, July 10, 1945 (K & Telford).

*Erioptera (Mesocyphona) caloptera* Say, 1823.—Glendale, July 9, 1943 (K & Telford); Leeds, June 27, 1945 (K); Washington, June 27, 1945 (K).

*Erioptera (Mesocyphona) distincta* Alexander, 1912.—Alton, June 28, 1945 (K); Amalga, May 30, 1944 (K & Stoddard); Bear River City, June 12, 1945 (K); Beaver, June 27, 1945 (K), July 11, 1945 (K & Telford); Brigham, May 27-June 17, 1938 (Hardy & Stains); Charleston, August 14, 1943 (K & Maddock); Duchesne River, west fork, July 24, 1945 (K); Echo, July 24, 1945 (K); Eden, June 29-August 30, 1943 (K & Telford); Ferron Reservoir, September 1, 1945 (Edmunds & Mulaik); Grover, August 20, 1939 (K & Harmston); Heber, August 14, 1943 (K & Maddock); Henefer, June 29, 1942, July 24, 1945 (K); Honeyville, June 16, 1945, July 31, 1942 (K); Hooper, September 3, 1937 (Hardy); Huntsville, June 9, 1938 (K & Stains); Hyde Park, June 11-13, 1938 (Hardy & Stains); Hyrum, June 6, 1938 (Hardy); Kamar, July 24, 1945 (K); Kanab, May 9, 1939 (K & Stains); Kanosh, June 27, 1945 (K); Kaysville, June 9, 1938 (K & Hardy); Lakota, July 24, 1943, July 29, 1945 (K); Leeds, August 8, 1942 (K & Peay); Leeton, July 25, 1945 (K); Logan, August 3, 1938 (K & Hardy); Logan Canyon, June 30, 1942; Mantua, August 1, 1942, September 4, 1943 (K); Midway, August 14, 1943 (K & Maddock); Moab, June 13, 1945, September 16, 1943 (K); Monte Cristo, August 12, 1943 (K & Maddock); Mt. Nebo, July 25, 1942, August 14, 1943 (K); Nephi, June 29, 1945, August 14, 1943 (K); Ogden, July 22, 1942 (K); Salt Lake City, April 14, 1934 (Rees), June 10, 1945 (Edmunds & Mulaik), June 13-August 21, 1939 (Rees); Smithfield, June 4, 1938 (Hardy); Spanish Fork, June 14-19, 1936 (Hardy), September 16-23, 1943 (K); Starr, June 29, 1945 (K); Three-Lakes, along Kanab Creek, August 9, 1942 (K & Peay); Mt. Timpanogos, July 26, 1945 (K); Washnapi, August 15, 1943 (K & Maddock); Washington, June 27, 1945 (K); Wellsville, July 21, 1942 (K); Wolf Creek Canyon, 9,400 ft., July 24, 1945 (K); Zion National Park, Weeping Rock, June 21-22, 1942 (M. M. Alexander), July 9, 1943 (K & Telford).

*Erioptera (Mesocyphona) dulcis* Osten Sacken, 1877.—Logan Canyon, at light, July 23, 1945 (K).

*Erioptera (Mesocyphona) eiseni* Alexander, 1913.—Brigham Canyon, August 1, 1942 (K); Mantua, August 1, 1942 (K); Moab, September 15, 1943

(K); Provo, June 8, 1935 (K & Nye), August 3, 1945 (K); Salt Lake City, August 30, 1945 (K); Zion National Park, 4,500 ft., June 21-22, 1942, June 28, 1945 (K).

*Molophilus (Molophilus) colonus* Bergroth, 1888.—Allen Canyon, July 24, 1943 (K & Maddock); Alton, June 28, 1945 (K); Beaver, June 27, 1945 (K), July 11, 1945 (K & Telford); Brigham Canyon, September 4-13, 1943 (K); Clinton, May 26, 1939 (K); Coalville, July 24, 1945 (K); Devils Slide, Weber Canyon, July 24, 1945 (K); Echo, July 24, 1945 (K); Eden, June 23, 1938 (Hardy & Stains), June 29, 1943 (K); Garden City, August 5, 1939 (K); Henefer, June 29, 1943 (K & Telford), July 24, 1945 (K); Hoytsville, July 24, 1945 (K); Layton, May 25, 1939 (K); Logan, at light, July 26, 1938 (K, Hardy & Stains); Logan Canyon, June 30, 1942; Mantua, September 4, 1943 (K); Monte Cristo, August 12, 1943 (K & Maddock); Ogden Canyon, August 5, 1939 (K); Provo, June 5, 1944 (K); Salt Lake City, City Creek Canyon, June 30, 1945 (K); Soldiers Summit, June 25, 1943 (K); Spanish Fork, June 8, 1936 (Hardy); Wolf Creek Canyon, July 24, 1945 (K); Woodland, July 24, 1945 (K); Zion National Park, June 21-22, 1942.

*Molophilus (Molophilus) harrisoni* Alexander, 1945.—Devils Slide, Weber River, from grassy banks, June 29, 1943 (K & Telford); Echo, June 29, 1943 (K & Telford), July 24, 1945 (K); Henefer, June 29, 1943 (K & Telford).

*Molophilus (Molophilus) perflaveolus* Alexander, 1918.—Logan Canyon, Lodge Forest Camp, 4,800 ft., June 30, 1942 (M. M. Alexander).

*Molophilus (Molophilus) spiculatus* Alexander, 1918.—American Fork Canyon, July 26, 1945 (K); Arches National Monument, September 16, 1943 (K); Beaver Canyon, Puffers Lake, June 6, 1936 (Hardy); Brigham, June 16, 1938 (Hardy & Stains); Brigham City, May 25, 1945 (Harmston); Eden, July 1, 1937 (Hardy); Fish Lake, July 10, 1943 (K & Telford); Hooper, August 9, 1937 (Hardy); Logan, July 17, 1938 (Hardy); Logan Canyon, 5,200 ft., June 30, 1942, Spring Hollow, August 5, 1943 (Maddock); Ogden, July 3, 1937 (Hardy); Provo (Hardy); Mt. Timpanogos, July 26, 1945 (Harmston); Wolf Creek Canyon, July 24, 1945 (K).

## The Life Cycle and Fertility of the Bridled Shiner, *Notropis bifrenatus* (Cope)\*

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It has been pointed out by Hubbs and Cooper (1936:11-12) that among cyprinid fishes, of those species building or guarding nests, the males acquire well-developed nuptial tubercles during the breeding season, and attain a larger size than the females do, and conversely, of those species neither building nor guarding nests, the females grow larger than the males, which develop only minute nuptial tubercles or none at all during the breeding season. They state also (p. 16) that "the males grow faster in those species in which males either guard or build nests," and "the females grow somewhat faster in those species which practice no parental care of the eggs," and that "the sex that grows the faster usually lives to a greater age." Observations by the author of the breeding habits of the bridled shiner, *Notropis bifrenatus* found this species to develop no nuptial tubercles and to practice no parental care, thus relegating it to the second category. However, in the matter of growth, though seeming to agree with the above formula, it actually does not.

It should be mentioned here that of several thousand specimens measured by the author, the largest was 45 mm. in standard length. Most authors give the maximum size of this species as about two inches in total length. The largest specimen of the many thousand examined by Bailey (1938:169) measured 48 mm. in standard length or 2 7/16 inches in total length.

In the collections studied by the author, no specimens were found that had passed more than two winters, thus indicating a life span of only two and a fraction years. On the basis of both scale annuli and length distributions, specimens were separable into two year-classes only, those that had passed one winter (Class I) and those that had passed two winters (Class II). On the scales of this species, the second annulus is always incisive, but the first annulus, although clear-cut in those specimens spawned early in the breeding season, is progressively less so in those spawned toward the end of the season. Some of these winter over in a very undeveloped state; one of them measured only 14 mm. in standard length as late as March. The range in size within a year-class, 14-33 mm. in standard length by March (Fig. 1, A and Table 1), is already apparent among the young of the year during their first summer of life (Fig. 2 and Table 3).

With few exceptions, male bridled shiners breed with females larger than themselves, and among the largest individuals of this species, females predominate. Yet analyses of two populations with respect to length, age and sex (Fig. 1, A and B and Tables 1 and 2), indicate that males grow more rapidly than females do. This is apparent from the length frequency distri-

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bution curves of Class I males and females. The trend is discernable by March in the displacement to the right of the curve for the length distributions of

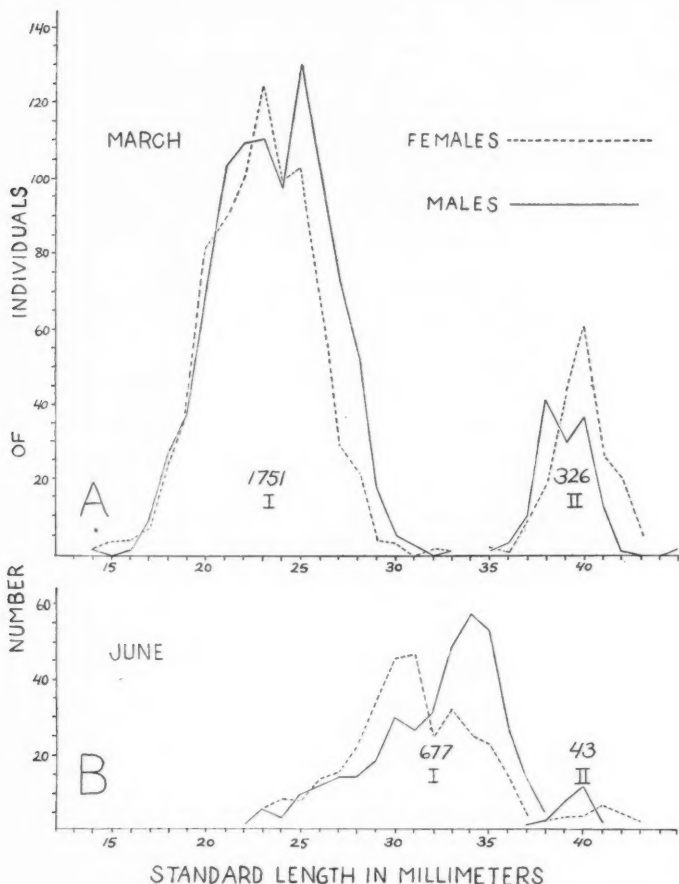


Fig. 1.—An early spring and a mid-breeding season population of *Notropis bifrenatus* compared. Roman numerals designate year classes. Class I comprises individuals having passed their first winter. Class II comprises individuals having passed their second winter. Adjacent Arabic numerals indicate the number of individuals in the respective year-classes. A.—Length frequency distributions of 2077 specimens collected March 21, 1938 in Fall Creek, Ithaca, New York. B.—Length frequency distributions of 720 specimens collected June 16, 1938 in the channel between the Suncook Ponds in Barnstead, New Hampshire.

the males (Fig. 1, A), and by June this displacement to the right (Fig. 1, B) reflects decisively the more rapid growth of the males.

In the case of Class II males and females, the situation appears at first to be reversed. With the exception of a single male 45 mm. long (Fig. 1, A and

TABLE 1.—The distribution with respect to length, age, and sex of 2077 bridled shiners, *Notropis bifrenatus*, collected March 21, 1938, in Fall Creek, Ithaca, New York. Roman numerals refer to individuals having passed their first and second winters, respectively.

Standard Length in mm.	Males		Females		Totals
	I.	II.	I.	II.	
45	—	1	—	—	1
44	—	—	—	—	—
43	—	—	—	6	6
42	—	1	—	20	21
41	—	14	—	27	41
40	—	37	—	61	98
39	—	30	—	42	72
38	—	41	—	19	60
37	—	11	—	9	20
36	—	3	—	1	4
35	—	1	—	2	3
34	—	—	—	—	—
33	1	—	1	—	2
32	—	—	1	—	1
31	2	—	—	—	2
30	5	—	3	—	8
29	18	—	4	—	22
28	54	—	22	—	76
27	74	—	30	—	104
26	101	—	69	—	170
25	130	—	103	—	233
24	97	—	99	—	196
23	110	—	124	—	234
22	109	—	101	—	210
21	103	—	89	—	192
20	68	—	81	—	149
19	38	—	38	—	76
18	26	—	25	—	51
17	9	—	7	—	16
16	1	—	3	—	4
15	—	—	3	—	3
14	1	—	1	—	2
I. Totals	947		804		1751
II. Totals		139		187	326
Grand Totals	1086		991		2077

Table 1), the females in general are the larger individuals. This male is a rare exception, for it was found to belong to the same age group. The apparent paradox is resolved when the sexes are compared with respect to maturity and with respect to mortality. It was found that although individuals of each sex mature and spawn after passing a single winter, males mature at a smaller size than females do. Milt from males as small as 25 mm. in standard length rendered eggs fertile, but no eggs from females smaller than 30 mm. in standard length were rendered fertile. Therefore, the more rapid growth and earlier attainment of maturity of the males would enable the majority of them to spawn their second summer, whereas the slower growth and later attainment of maturity of the females would prevent a larger proportion of

TABLE 2.—The distribution with respect to length, age, and sex of 720 bridled shiners, *Notropis bifrenatus*, collected June 16, 1938, in the channel between the Suncook Ponds in Barnstead, New Hampshire. Roman numerals refer to individuals having passed their first and second summers, respectively.

Standard Length in mm.	Males		Females		Totals
	I.	II.	I.	II.	
43	—	—	—	2	2
42	—	—	—	4	4
41	—	2	—	6	8
40	—	11	—	3	14
39	—	7	—	3	10
38	4	2	—	2	8
37	13	1	3	—	17
36	26	—	14	—	40
35	53	—	22	—	75
34	57	—	25	—	82
33	48	—	31	—	79
32	31	—	24	—	55
31	26	—	46	—	72
30	29	—	45	—	74
29	18	—	34	—	52
28	14	—	22	—	36
27	14	—	15	—	29
26	11	—	13	—	24
25	9	—	8	—	17
24	3	—	8	—	11
23	5	—	5	—	10
22	1	—	—	—	1
I. Totals	362		315		677
II. Totals		23		20	43
Grand Totals	385		335		720

them from spawning their second summer. The single large male is of the size to be expected of males surviving to spawn a second time, i.e. during their third summer of life. The general absence of such males of maximum size can be explained best by the assumption that most of them spawn during their second summer and that few survive to spawn again, during their third summer. The other males of Class II are probably those which did not mature sufficiently to spawn during their second summer, but which survived to spawn for the first time, during their third summer.

This mechanism would ensure a predominance of smaller ripe males in relation to the ripe females, which is the situation encountered over the spawning beds. At one breeding site, out of 29 individuals, 26 were males

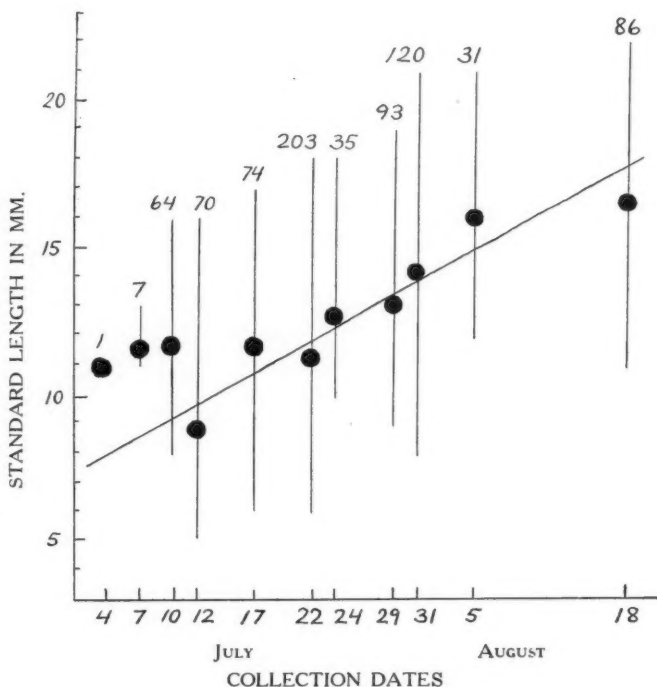


Fig. 2.—The mean growth of young bridled shiners during their first summer in the Oyster River at Durham, New Hampshire in 1942. The solid vertical line represents the range in standard lengths of the fish in the collection concerned. The numeral above the line indicates the number of specimens measured. The first three points are ignored, since they represent collections in which the smaller individuals were lacking although they were obviously the most numerous size class at the time. Of small size and thinly distributed within the dense wood cover or on the bottom beneath it, they escaped collection.



TABLE 3.—The standard lengths of *Notropis bifrenatus* young of the year from 11 collections, arranged in frequencies of one millimeter.

Stand. Length in mm.	Collection Dates — 1942											
	July								August			
	4	7	10	12	17	22	24	29	31	5	18	
5	—	—	—	6	—	—	—	—	—	—	—	—
6	—	—	—	5	3	1	—	—	—	—	—	—
7	—	—	—	8	—	6	—	—	—	—	—	—
8	—	—	1	17	3	13	—	—	1	—	—	—
9	—	—	7	8	11	23	—	2	2	—	—	—
10	—	—	11	9	9	39	4	6	3	—	—	—
11	1	4	11	7	11	40	7	13	9	—	2	—
12	—	2	14	5	9	22	7	14	12	3	3	—
13	—	1	9	3	9	24	7	18	11	2	5	—
14	—	—	7	1	7	15	3	21	30	6	13	—
15	—	—	2	—	5	10	5	11	22	4	10	—
16	—	—	2	1	5	5	—	2	16	3	13	—
17	—	—	—	—	2	2	1	2	8	4	9	—
18	—	—	—	—	—	—	3	1	2	2	3	9
19	—	—	—	—	—	—	—	2	1	3	8	—
20	—	—	—	—	—	—	—	—	1	1	9	—
21	—	—	—	—	—	—	—	—	2	2	4	—
22	—	—	—	—	—	—	—	—	—	—	1	—
Totals	1	7	64	70	74	203	35	.93	120	31	86	
Mean Stand. Length	11.0	11.6	11.7	8.8	11.7	11.3	12.7	13.1	14.2	16.0	16.5	

and only 3 were females. This is typical of breeding groups, which were never large at any particular site. The largest Class II females then, may breed with the smaller Class II males, the smaller Class II females with the largest Class I males, and so on, thus maintaining the observed functional sexual dimorphism in size. The actual sex ratios, shown in Table 4 reveal the production of more males than females by this species, and in other ways tend to reinforce the functional ratio of more and smaller ripe males to fewer and larger ripe females.

The spawning period of *Notropis bifrenatus* was found to extend from the last week of May to the middle of July in Durham, New Hampshire, and is considered by Wright and Allen (1913) to extend from May 2 to August in Ithaca, New York. In either case, the height of activity probably occurs in mid-June. Assuming mid-June to be the time of birth of the majority of individuals in the March collection from Ithaca, those in Class I would be approximately 9 months old and those in Class II, 21 months old. The number of fish in Class II is 18.56% of that in Class I. Thus the mortality among those specimens just surviving their second winter is over 80% of the number of fish in the corresponding age-class a year younger, i.e. just

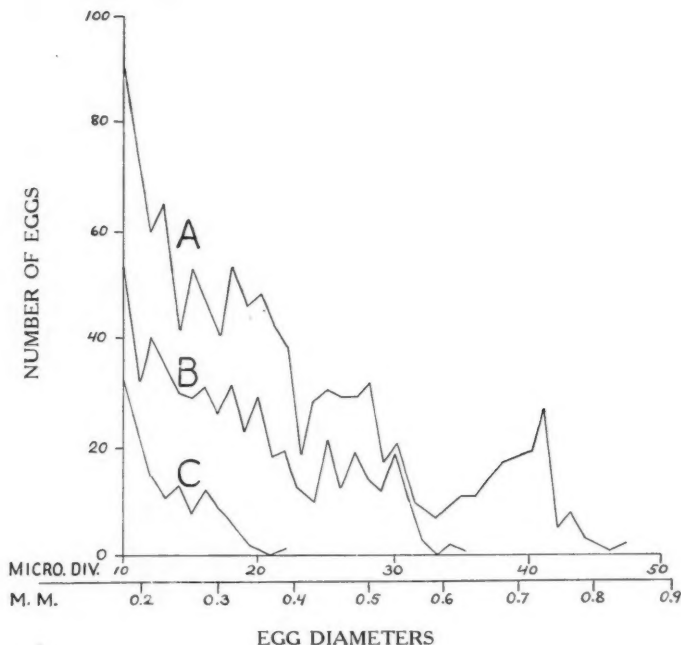


Fig. 3.—The egg-diameter distributions in the ovaries of three females of *Notropis bifrenatus*, grouped in frequencies at each micrometer division. One ovary from each specimen was examined. All eggs containing a perceptible amount of yolk were counted and their diameters measured. The diameters of 1721 eggs were measured. A.—Curve for 1055 eggs from a female 44 mm. in standard length and in its third summer. B.—Curve for 531 eggs from a female 34 mm. in standard length and in its second summer. C.—Curve for 135 eggs from a female 25 mm. in standard length and in its second summer. These specimens were from the collection of June 16, 1938 analyzed in Table 2 and in Fig. 1, B. They were preserved in formalin and in alcohol and the eggs were transferred to cedar oil.

surviving its first winter. By the middle of the breeding season in June, Class II individuals become even fewer proportionately (Fig. 1, B). From this it would appear that the chief responsibility for the reproduction of young required to maintain this species devolves on those fish maturing and spawning their second summer.

If, in general, males 25 mm. in standard length and larger become functionally mature, then 97% of the males in Class I of the June collection could have spawned their second summer. If females smaller than 30 mm. in stan-

ard length do not become functionally mature, then about 34% of those in Class I would not have been able to spawn until their third summer. Although these figures must be considered with reservations, they help to particularize the trend noted above.

TABLE 4.—Actual Sex Ratios: Males to Females.

	Entire collection	Class I	Class II
March Population	1.10:1.00 (2077 specimens)	1.18:1.00 (1751 specimens)	1.00:1.35 (325 specimens)
June Population	1.15:1.00 (720 specimens)	1.15:1.00 (677 specimens)	1.15:1.00 (43 specimens)

Field observations disclosed a long breeding period for this species and some evidence of the successive attainment of maturity by individuals of different age and size, but did not reveal over how long a period a single fish may spawn, nor the fertility of the individual fish. With respect to the last two problems, a study was made of the ovaries of the largest Class II female, and also of one of the larger and of one of the smaller Class I females of the June collection. One ovary was removed from each, all eggs containing a perceptible amount of yolk were counted, and their diameters measured with an ocular micrometer. The method of measurement employed is that of Clark (1925:151), who established its statistical validity. The ovary of a female 44 mm. in standard length contained 1055 yolked eggs in different stages of development, that of a 34 mm. female, 531, and that of a 25 mm. female, 135. The figures obtained by doubling these numbers to account for the other ovary, 2110, 1062, and 270, respectively, are undoubtedly too large for the actual fertility of these fish. The range in egg diameters was from 0.2 mm. to 0.8 mm. (Fig. 3 and Table 5), and it is unlikely that the smaller eggs would have developed to maturity during the remainder of the breeding season. Sections of the ovaries not used in counting and measuring showed eggs of the same size as the smallest measured to contain yolk only in the form of globules in the light-colored cytoplasm and to have clearly visible nuclei. In eggs smaller than these, there was no yolk, and the cytoplasm stained deeply. In larger eggs, the yolk increases with increase in diameter, gradually obliterating both nucleus and cytoplasm. A second stage is attained with the acquisition of a zona radiata at diameters of approximately 0.46 mm. Only in eggs of at least 0.6 mm. in diameter was a micro-pyle present.

The immaturity of the smallest fish is evident from the curve of its egg-diameter distributions (Fig. 3, C), and confirms both field observation and the negative results of attempts to fertilize the eggs of a fish of this size. The 34 mm. fish must have been either not fully mature or must have spawned its current quota of fully ripe eggs (Fig. 3, B), for females smaller than this

yielded eggs which were easily fertilized artificially. It is quite possible that it was not fully mature as the June collection was made at Barnstead, New Hampshire which is somewhat north of Durham, New Hampshire, where the breeding season was delimited by the author in 1946. The 44 mm. female contained the largest eggs and the greatest number of them; the egg-mass was compact and no eggs seemed to have been spawned.

Hickling and Rutenberg (1936:311 *et seq.*) suggest that in the case of a long spawning period, the withdrawal of eggs from the general egg-stock to

TABLE 5.—Frequencies of egg-diameters at each micrometer division. Measurements were taken on all eggs with a perceptible amount of yolk in one ovary of each of the following: (A) Class II female, 44 mm. in standard length, (B) Class I female, 34 mm. in standard length, (C) Class I female, 25 mm. in standard length.

Micro. div.	mm.	A	B	C
10	0.18	90	54	32
11		77	32	24
12		60	40	15
13		65	35	11
14		42	30	13
15	0.27	53	29	8
16		45	31	12
17		40	26	9
18		53	31	7
19		46	23	2
20	0.36	48	29	1
21		42	18	—
22		38	19	1
23		19	12	—
24		28	10	—
25	0.45	29	21	—
26		28	12	—
27		28	18	—
28		31	14	—
29		17	12	—
30	0.53	20	19	—
31		10	10	—
32		9	3	—
33		7	—	—
34		9	2	—
35	0.62	11	1	—
36		11	—	—
37		15	—	—
38		17	—	—
39		19	—	—
40	0.71	27	—	—
41		5	—	—
42		8	—	—
43		3	—	—
44		2	—	—
45	0.81	1	—	—
46		2	—	—
Totals		1055	531	135

be matured will be a continuous process with no sharp separation between egg-stock and maturing eggs, but in the case of a short spawning period, the eggs to be matured and spawned will be withdrawn in a single batch sharply separated from the stock of small eggs. They found their hypothesis to hold in the case of several species of salt-water fishes of known spawning habits, and offer it as a method of predicting the length of the spawning period of little known species. In the curves of the egg-diameter distributions of *Notropis bifrenatus* (Fig. 3) there is no sharp separation between those eggs in the later stages of maturation and those of the general egg-stock from which they were derived, the many undeveloped eggs passing continuously into the fewer maturing eggs. They thus fulfill the conditions of the hypothesis indicative of a long spawning period. To what degree this criterion is applicable to fresh-water species in general remains to be seen for at present there seem to be no published data permitting a comparison of the egg-diameter distributions of fresh-water species having long spawning periods with those having short ones. Furthermore, a long spawning period for a salt-water species appears to be of much greater duration than that regarded as long for a fresh-water species.

In conclusion, it should be mentioned that the bridled shiner is subject to heavy depredations by predators being of small size and a weak swimmer. Although spawning relatively few eggs per female, it has maintained itself successfully in spite of its very brief life span by the early attainment of sexual maturity. It has crossed the St. Lawrence River into Canada in comparatively recent times, and is considered by Radforth (1944:78) to have by no means reached the limits of its northern distribution.

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## Eggs, Larvae, and Attending Females of *Desmognathus f. fuscus* in Southwestern Ohio and Southeastern Indiana

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Bishop (1943) observes that adult *Desmognathus f. fuscus* are very variable in color and pattern, and King (1939) reports that isolation is responsible for consistent variations found in geographically separated groups. Comparison is here made between Bishop's (1941) records from Rochester, New York, and those of the authors from southwestern Ohio and southeastern Indiana, (the NW periphery of the known range), the problem being to determine whether consistent marked variations are found in characteristics other than color and pattern. The three items chosen for contrast are:

- (a) number of eggs found under natural conditions attended by a single female;
- (b) size of larvae at time of emergence, and dates;
- (c) size of attending females.

Morse (1904) reports *D. f. f.* very common in all parts of Ohio. Bishop (1943) illustrates the western Ohio distribution as known only from the southern quarter of the Miami Valley. Finding this species at Germantown Dam, Montgomery County, Ohio, may establish a new northern limit to the known range in SW Ohio.

The Germantown Dam habitat is the bed of a small brook which cut abruptly down the east bank of Bear Creek ravine one-half mile N of the dam. The *Acer-Betula* community provides deep shade over the limestone shelf outcroppings through which the brook bed is cut. On Sept. 7, 1945 seven females and their egg masses were collected from this area, and on Oct. 5, 1946 one female and 36 larvae found with her were collected.

The habitat of Derbyshire Falls, Franklin County, Indiana, was very similar in plant life and rock formation. A female with young and eggs taken there Oct. 5, 1946 were found at the base of a dried-up falls.

*Females.*—All specimens mentioned attending eggs and larvae in the preceding section are considered in this average. Of nine specimens measured the average total length was 91.8 mm (range interval 17.8 mm, extremes 81.5 and 99.3). Bishop (1941) averaged a series of 65 adult females from vicinity of Rochester, N. Y. Average total length 82.5 mm (range interval 34.0 mm, extremes 66 and 100).

Tail length averaged 49.7% of total length in the 9 Ohio and Indiana specimens, 47.2% in Bishop's series.

Bishop (1941) found females with eggs in a variety of habitats including examples from beneath accumulations of dead leaves or layers of moss. All females collected for this report were found in exactly the same type of habitat—beneath a thin slab of limestone lying in a slanted position on clay or loam, with a shallow depression beneath.

An adult female collected with eggs September 1, 1945 was dissected for examination of ovarian eggs. At that date full series of eggs were observed in each ovary, egg diameter approx. 0.5 mm.

*Eggs*.—Bishop (1941) found that the number of eggs with a single female averaged 17 (range 12-26) in the Rochester area. The eggs from seven females collected Sept. 1, 1945 totaled 183, averaging a fraction more than 26 eggs to the female. The embryos and larvae found with single females October 5, 1946 averaged 27 to the female.

*Larvae*.—Bishop (1941) measured 50 larval *Desmognathus f. fuscus* August 25, 1925 as they hatched. Average total length 16.2 mm (range interval 2.5 mm, extremes 15.0 and 17.5 mm). One of the egg masses collected September 1, 1945 had larvae begin emerging at once, after eggs had been placed in water. The troglodyte embryos which had transformed into free-swimming aquatic larvae were preserved and measured at once. Average total length was 13.3 mm (range interval 1.0 mm, extremes 12.8-13.8 mm).

The 36 larvae from Germantown Dam Oct. 5, 1946 averaged (total L.) 18.2 mm, extremes 15.9 and 20.0 mm. The 18 larvae from Derbyshire Falls October 5, 1946 averaged (total L.) 18.3 mm, extremes 17.1 and 19.3 mm. Three of the larvae measured in the Derbyshire Falls series emerged from the egg membranes shortly after collection.

Dissection of eggs from another egg group collected in the September 1, 1945 series from Germantown Dam indicated that the larvae in that series, still encased in the embryonic membranes, had attained a total length of 10.0 mm.

Measurements of a 13.8 mm larva collected September 1, 1945 are: head length 3.0 mm, head width 2.0 mm, body length 5.9 mm and tail length 4.9 mm. Percent tail in this larva, 35.6. Percent tail in 19.3 larva, 40.5.

The size of the yolk abdominal bulge varied greatly, being largest in the small specimens. In the 13.3 mm larva, the bulge measured (lateral view) 4.0 mm long and 2.0 mm high.

#### SUMMARY AND CONCLUSIONS

1. Average total length of female *Desmognathus f. fuscus* with eggs in SW Ohio is 9.3 mm greater than the average of 65 adult female specimens from Rochester, N. Y.
2. Average percent of total length of tails with these same specimens was 2.5% greater in SW Ohio, although it appears that larger specimens have higher tail ratios.



3. Average size of larvae, at time of hatching in SW Ohio and SE Indiana, ranges from a minimum total length of 12.8 mm to a maximum of 19.3 mm, average size in any brood depending on date of emergence.
4. Emergence of larvae possibly far earlier than indicated by Bishop's average total length of 16.2 mm if an aquatic environment is provided.
5. Habitats where females were found attending eggs were less varied in SW Ohio than in Rochester, N. Y. area.
6. Females found guarding their egg clusters already have well developed ovarian eggs (0.5 mm diameter) at time when larvae are ready to emerge.
7. Maximum number of eggs found with a single female in Rochester area was slightly less than the average for SW Ohio females. SW Ohio females had 53.3 percent larger egg clusters than found with females in Rochester area.
8. Larvae found emerging on September 1, 1945 and October 5, 1946 in SW Ohio and SE Indiana, but not later than August in Rochester area.

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## New Distributional Records for *Xantusia vigilis* with Observations on its Habitat

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On April 19, 1935, a yucca night lizard, *Xantusia vigilis*, was captured and at least two others were seen by Brighton C. Cain at Pinnacles National Monument, San Benito County, California. The discovery was surprising since the Pinnacles are situated 165 miles in an air line northwest of the nearest locality of previous record, and the habitat there represents a considerable departure from that occupied by the species elsewhere. The lizard was deposited in the Museum of Vertebrate Zoology. It came to the attention of Dr. Jean M. Linsdale and Mr. Thomas L. Rodgers of the Museum's staff, but a report of the discovery was postponed in the hope that additional material would come to hand. There was thought to be a chance that the animals had been artificially introduced in the Pinnacles area.

In 1946 the author made several trips to the Pinnacles in search of this lizard and it can be announced now that it is of natural occurrence there.<sup>1</sup> Seventeen individuals have been obtained. Although they are closely similar to other representatives of the species, they are slightly different in scalation and pigmentation, which circumstance supports the view that they are native to the region. These differences are discussed later.

The noteworthy aspect of the discovery lies less in the extension of the range of the species than in the environmental setting in which the animals occur. *Xantusia vigilis* has been considered one of relatively few vertebrates that exhibits close association with a plant type. Its range corresponds closely with the distribution of plants of the genus *Yucca*. Although previous records of occurrence have by no means indicated that the lizards are invariably restricted to association with these plants, by far the majority of individuals have been found in areas where they are abundant. They occur beneath dead fallen trees and limbs and among the spiny leaves of Joshua trees (*Yucca brevifolia*) and beneath the rosettes or among the leaves of dead Spanish dagger (*Y. mohavensis*) or Quixote plants (*Y. whipplei*). So far as my information goes, based on personal investigation of the area and the statements of residents, yuccas do not occur naturally within the boundaries of Pinnacles National Monument, although *Y. whipplei* is of sparse occurrence on the hills along the San Benito River a few miles to the east. According to Jepson (1923-1925), this is the northern limit of its distribution in the Coast Ranges. Thus a degree of correspondence between the distribution of yuccas and that of the lizard is retained, even though the scarcity of the plants in west central San Benito County has made use of other types of cover by the animals imperative.

The plant that appears to take the place of the yucca in the ecology of

<sup>1</sup> Messrs. Wade Fox, John Davis, and Lee Talbot have aided in the search for the lizards.

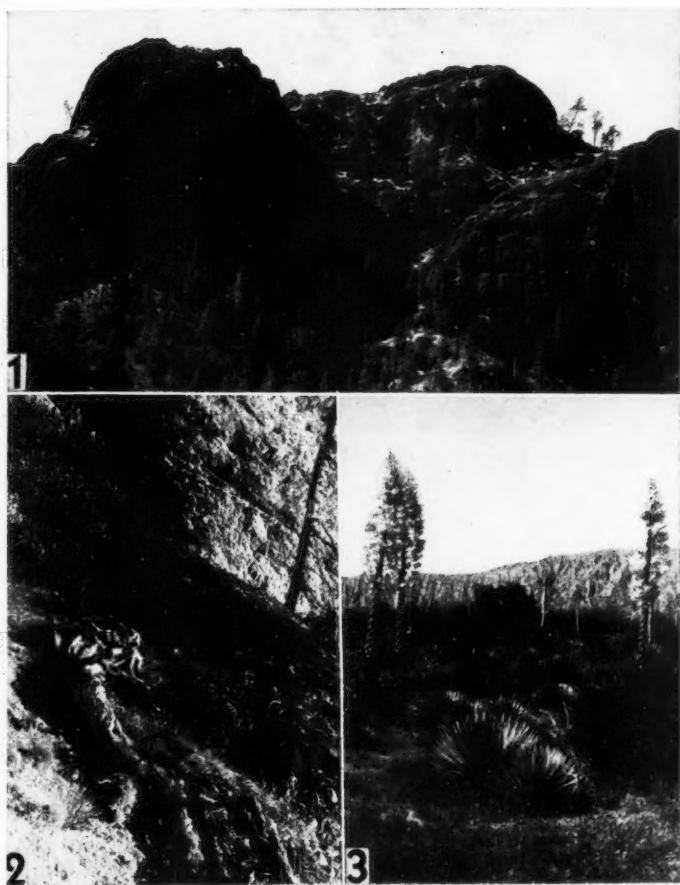


Fig. 1. West wall of the canyon west of High Peaks, Pinnacles National Monument, San Benito County, California. The dominant trees are Digger pines. Coast live oaks are concentrated at the foot of the cliffs and in the gully in the center foreground. On October 6, 1945, 7 *Xantusia vigilis* were found in an hour's time beneath Digger pine logs on the slope below the cliffs.

2. A Digger pine log of a type which might be expected to yield a *Xantusia*. Well fissured logs appear to be favored by the lizards. Such logs provide numerous niches in which they may seek shelter and at the same time afford an abundant food supply of termites and other arthropods.

Fig. 3. Stand of *Yucca whipplei*, 11 miles west and 13 miles north of Mount Pinos, Santa Barbara County, California. On May 11, 1945, in about an hour's time, 15 *Xantusia vigilis* were found here beneath dead yucca plants.

the lizards at the Pinnacles is the Digger pine (*Pinus sabiniana*), for here they occur principally within and beneath Digger pine logs. Of the 17 individuals taken, 15 were so situated. Of the remainder, one was procured beneath a rock and the other, collected by Cain, may have come from beneath a coast live oak log. Other types of surface objects—rocks, oak logs, and other plant debris—have been searched as persistently as the Digger pine logs; thus the occurrence of the lizards in the latter is not a reflection of the selection of such logs by the collector. More rocks were turned than other surface objects, but only one lizard was found in this way.

#### THE HABITAT AT PINNACLES NATIONAL MONUMENT

Figs. 1 and 2

The region is characterized by rocky outcrops, imparting a rugged outline to this portion of the interior Coast Range, a departure from the more common, rolling contours of the mountains elsewhere. The dominant rocks are volcanic breccias and tuffs, the former rough surfaced. Although the rocks provide good footing for nocturnal wanderings of *Xantusia*, there are few crevices, apart from talus areas, into which the lizards might retreat.

The region is semi-arid, with chaparral the dominant plant cover. The

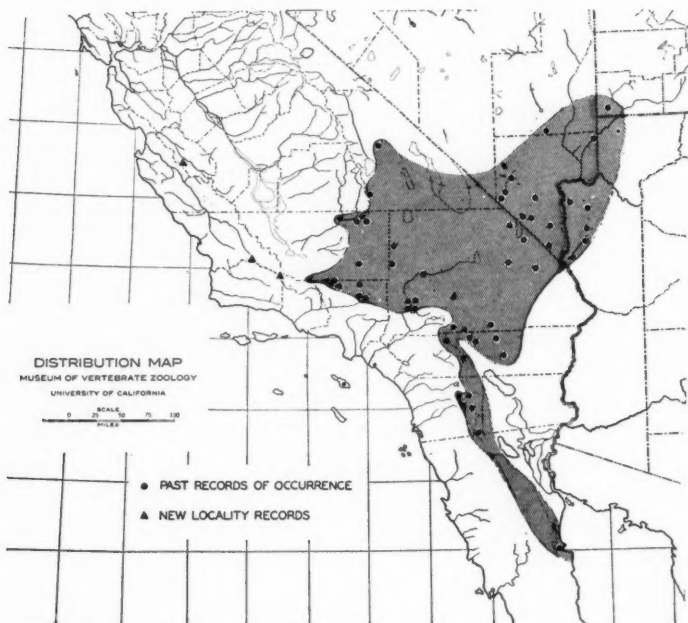


Fig. 4. Distribution of *Xantusia vigilis*. The extension of the range is in the interior Coast Range of California.

more abundant chaparral species are chamise (*Adenostoma fasciculatum*), *Ceanothus cuneatus*, and manzanita (*Arctostaphylos glauca*). The xeric plants *Selaginella bigelovii* and the fern *Pellaea ornithopus* occur upon and among the rocks. Common trees of the region are coast live oak (*Quercus agrifolia*), Digger pine (*Pinus sabiniana*) and buckeye (*Aesculus californica*). Streams of the area are for the most part intermittent.

Surface litter is not abundant. Leaf mold, consisting principally of oak leaves and pine needles, is spotty in occurrence. In the chaparral areas, there is an extensive dark litter composed of the leaves and fruits of chaparral plants, but there are few logs adequate as cover for the animals. In searching for the lizards, considerable time was spent in locating suitable oak and Digger pine logs, for they are not abundant.

Most of the animals came from well rotted logs of considerable size (an average log was five feet long and a foot and a half in diameter). One was found beneath a log which still had its bark intact and the wood firm and uncracked. A well fissured Digger pine log is not unlike the spiny leaved limb of a Joshua tree in providing numerous interstices in which the lizards may seek shelter. Oak logs seem less inclined toward checking, perhaps due to the more irregular grain, than the pine logs and they occur in more shaded situations. Both factors may be involved in the apparent tendency for the lizards to avoid these logs. Food supply does not seem to be as important in such selection since termites and other insects appear to be of similar abundance in the two types of logs.

Arthropods observed in places harboring *Xantusia* were spiders, centipedes, silverfish, tenebrionid and other beetles, termites, ants, camel crickets and other crickets. The stomachs of individuals examined possessed principally ants.

Reptilian associates of *X. vigilis* at the Pinnacles are the fence lizard, *Sceloporus occidentalis*, and the spotted night snake, *Hypsiglena ochrorhynchus*. Both have been found in Digger pine logs. *Sceloporus* is probably not important as a competitor since it is primarily a diurnal surface feeder whereas *Xantusia* is nocturnal and probably does most of its foraging beneath and within logs. It is likely that the night snake preys on *Xantusia* in nature, as Cowles (1941) has found that this snake feeds readily on *X. vigilis* in captivity. Skinks, *Eumeces skiltonianus* and *E. gilberti*, were found just outside the Monument under bark and beneath logs and doubtless they should be listed here also. They may compete to some extent with *Xantusia* for food.

Familiarity with the occurrence of *Xantusia vigilis* in the Mohave Desert of California and in other xeric regions of the southwest causes one to look upon the association of this lizard with salamanders with surprise. The arboreal salamander (*Aneides lugubris*), slender salamander (*Batrachoseps attenuatus*), and probably the brown salamander (*Ensatina eschscholtzii*) are present in the habitat at the Pinnacles. These plethodonts occur within and beneath logs and under other surface objects when the soil is damp, and it is likely that occasionally one or another of them and the yucca night lizard occur together, a situation which according to present knowledge could not arise in any other part of the present known range of the species.

## TAXONOMIC STATUS

The *Xantusia* obtained by Cain differed in pigmentation, head shape, and in the form of the frontoparietal head plates from *X. vigilis* from other areas. These differences, in conjunction with the location of the collection site in relation to the previously known range of the species, suggested strongly that the population at the Pinnacles would show differences of sufficient magnitude to make desirable recognition of a race in this region.

The additional specimens show that the differences between the population at the Pinnacles and the typical form are so slight that, in my opinion, nothing is to be gained by applying a name to them. Races have been described on as tenuous differences as are present here, but the desirability of naming such weakly differentiated populations is strongly to be questioned.

The question as to whether or not a name should be applied should not be allowed to distract attention from the following significant facts: (1) differentiation is correlated with a habitat differential; (2) differentiation is weak and may be correlated with a probable recent invasion of a new habitat. We are viewing an example of microevolution on an infra-subspecific level.

Characteristics of the animals from the Pinnacles (17=8 males, 7 females, and 2 subadults) are as follows: snout more slender than in typical *vigilis*, a difference not readily demonstrated by measurement but one found quite reliable in segregating animals by eye; pigmentation averaging somewhat heavier and pattern more sharply defined, particularly that on head and neck; 64 per cent of animals with frontoparietal head plates separated by contact of frontal and parietal, or the four plates—parietal, frontoparietals, and frontal—meet at midline with sutures separating them forming an X; by contrast, in a series of 22 animals from Kern County and 15 from Santa Barbara County, 18 per cent and 6 per cent, respectively, were so characterized; remaining Pinnacles animals have frontal and parietal separated by frontoparietals which are in contact with one another along a median longitudinal suture. Scale counts employed by Klauber (1931) in his comparisons of the species of *Xantusia* were made, but the figures fall within the range of variability of *X. vigilis* from other areas. The overlap in the range of variation of most of these characters is sufficiently great to make segregation of individuals from a mixed sample inaccurate to a degree undesirable for a nomenclatorially recognized population.

## OTHER NEW RECORDS OF OCCURRENCE

Cowles (1944) found *Xantusia vigilis* beneath the dead rosettes of the Quixote plant at Frazier Park above Fort Tejon, Los Angeles County, California. Until now, this had been the westernmost record for the species. Frazier Park lies in a valley southeast of Mount Pinos. Its eastern boundary marks the westernmost penetration of Joshua trees, which occur a few miles southeast of the Park entrance on the west side of U. S. Highway 99. Here the trees are much dwarfed, possibly due to less favorable conditions. The Joshua trees in this area represent an extension westward from Antelope Valley, where *Xantusia vigilis* is abundant. At Frazier Park the tree yucca is replaced by the Quixote plant, which is of scattered occurrence through Lockwood and Cuyama valleys and thence northward in the Coast Ranges as far

as central San Benito County. Recently, I looked for *Xantusia* in stands of *Yucca whipplei* west and north of Frazier Park.

On May 11, 1945, Mr. John Davis and I searched a dense stand of Quixote plants about 200 feet east of U. S. Highway 399, 11 miles west and 13 miles north of Mount Pinos, Santa Barbara County, California (Fig. 3). Between 1:30 and 2:50 p. m., we obtained 15 *Xantusia* and could have taken more but our time was short. At least 7 others escaped. All were obtained by overturning dead plants in an area about 200 feet in diameter.

The general character of the region is one of aridity. The yuccas occur in clumps on a gently west-sloping alluvial fan. Hills to the east, about 1/4 mile away, are much eroded, and with little vegetation. No yuccas can be seen upon them. Other plants in the area are desert-tea (*Ephedra californica*), juniper (*Juniperus californicus*), and buckwheat (*Eriogonum fasciculatum*) with grass in open areas between these plants. The soil is whitish to buff in color, composed of firmly packed, coarse sand. Litter beneath the yucca clumps is dark-colored, almost black, against which the lizards were difficult to see until they moved.

On July 19, 1946, my wife and I searched an isolated clump of 75-100 plants on the northeast side of State Highway 166, 29 miles east of Santa Maria, San Luis Obispo County, California. We found a shed skin and 2 adult *Xantusia*, one of which escaped. The yucca stand was on a steep embankment which sloped 50-55° to the southwest. The surrounding country was grassland with blue oak concentrated in ravines and canyon bottoms.

*Xantusia vigilis* is a lizard that, due to its small size and secretive habits, long existed in obscurity until the secret of its hiding place among the Joshua trees was discovered by John Van Denburgh (1895) in 1893, after which it was found to be one of the most abundant lizards. With the discovery of this lizard in Digger pine country at the Pinnacles, search should be made for it in other areas where these trees occur. Probably the species will be found farther north in the Coast Ranges than the Pinnacles, and the Digger pine-covered foothills of the Sierra may also prove a fertile field for investigation. Stands of *Yucca whipplei* in the coastal mountains of southern California also should be given the attention of collectors. The range of the yucca night lizard may prove to be even much more extensive than now known, and it may include still further ecologically diverse habitats.

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# Studies on the Muscles of the Pelvic Appendage in Birds II: The Heterogeneous Order Falconiformes

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## INTRODUCTION

This paper continues investigations on the comparative anatomy of the musculature of the pelvic limb in birds (Hudson, 1937) with the purpose of determining the modifications characteristic of the various orders and other major taxonomic groups. No attempt has been made to study innervations. It is hoped that other investigators will enter the almost virgin field of comparative avian neurology. The same applies to the study of the circulatory system, digestive system and the anatomy of other "soft" parts, which are still greatly neglected fields of ornithological research. It is amazing to note that there is not in existence today a single comprehensive and authoritative work on the complete anatomy of the domestic fowl, or for that matter, of any species of bird.

It hardly seems necessary to state that in the comparisons of the various suborders, families and genera, no claim is made that the results given here hold for all individuals and species of these groups. These findings apply only to the forms listed as examined under the heading "Material and Methods". The study of additional forms, particularly the many genera of Accipitridae and Falconidae not available to me, is strongly recommended for anyone fortunate enough to obtain the necessary specimens. It is also desirable

that additional specimens of *Pandion haliaetus* and *Sagittarius serpentarius* be examined and critically compared with the descriptions given here.

The names of muscles follow those of my previous paper since no sufficiently comprehensive work has appeared that would justify making any changes.

#### MATERIAL AND METHODS

Specimens were preserved in formalin in the usual manner and later transferred to 70 percent alcohol. The following were studied by gross dissection:

Family CATHARTIDAE	Swainson's hawk ( <i>Buteo swainsoni</i> ).....1
Turkey vulture ( <i>Cathartes aura</i> ).....2	Golden eagle ( <i>Aquila chrysaetos</i> ).....1
Black vulture ( <i>Coragyps atratus</i> ).....2	Marsh hawk ( <i>Circus cyaneus</i> ).....1
Family SAGITTARIIDAE	Family PANDIONIDAE
Secretary bird ( <i>Sagittarius serpentarius</i> ).....1	Osprey ( <i>Pandion haliaetus</i> ).....1
Family ACCIPITRIDAE	Family FALCONIDAE
Cooper's hawk ( <i>Accipiter cooperii</i> ).....1	Sparrow hawk ( <i>Falco sparverius</i> ).....2
Red-tailed hawk ( <i>Buteo jamaicensis</i> )...2	Pigeon hawk ( <i>Falco columbarius</i> ).....1
	Duck hawk ( <i>Falco peregrinus</i> ).....1
	(shank and foot only)

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I wish to express my grateful appreciation to Mr. Henry M. Kennon who made available a secretary bird that met an accidental death at the St. Louis Zoo and to Mr. E. A. McIlhenny of Avery Island, Louisiana, who generously supplied me with four living black vultures.

#### REVIEW OF RECENT LITERATURE

From a study of the pterylosis of various species of the Order Falconiformes and a consideration of the deep plantar tendons, Compton (1938) concluded that the osprey (*Pandion haliaetus*) should be placed in the Suborder Cathartae with the American vultures, but in a separate family, Pandionidae.

Howell (1938) studied the muscles of the hip and thigh in the domestic fowl (*Gallus*) and on this basis designated many of these muscles by names differing from those used by Gadow (1891) and Hudson (1937). He states, however, that in his paper, "Cases of individual muscles have been argued according to the evidence that is available to me, and the homologies that seem most reasonable have been chosen . . . some of them only tentatively. It is hardly possible that every one of them will stand the test of time."

I believe that anyone conversant with the situation will agree that homologies of bird muscles with those of other vertebrate classes are far from firmly established, and although Dr. Howell is eminently qualified to make such a study, it should be emphasized that investigation of a single species cannot be considered as an adequate basis for renaming muscles. I would like to urge Dr. Howell or some other qualified comparative anatomist to carry out similar studies on representatives of fifteen or twenty orders of birds. If this were done any changes in terminology of muscles that might be indicated by such a comprehensive investigation could be adopted with confidence. However, until such a study is made I do not believe that any radical changes in the names used for bird muscles are justified. Such changes only add to the confusion and make more difficult an already complicated field of study.

Fisher (1946) made a thorough study of the locomotor apparatus of New World vultures based on material representing all five living genera. Bones and muscles of both the pectoral and pelvic appendages and the tail are considered. The muscle names employed (Tables 19 and 42) are a mixture of terminology used by several writers. Although Howell (1938) clearly indicated the tentative nature of his work on avian homologies, his names are followed closely for muscles of the hip and thigh. Names for muscles of the shank and foot are those used by Hudson (1937). Many muscles of the wing are named according to Shufeldt (1890) instead of Gadow (1891) or Fürbringer (1902), much more authoritative references.

Fisher (1946) gives much attention to the probable functions of muscles and muscle groups to explain the differences in locomotion between the various genera of vultures. He went about as far with this as could be expected from a study of preserved material and observations of living birds. Experimental studies involving excision of certain muscles in living specimens would doubtless throw much light on this aspect of the subject. Fisher's work on the muscles of American vultures is the most detailed study that has appeared in this country on the myology of any single group of birds.

#### REVIEW OF THE MUSCLES OF THE PELVIC LIMB

##### M. ILIO-TROCHANTERICUS POSTERIOR (Il. troc. post.)

*M. gluteus profundus*—Fisher, 1946, p. 659.

Typical in all forms examined.

##### M. ILIO-TROCHANTERICUS ANTERIOR (Il. troc. ant.)

*M. iliacus*—Fisher, 1946, p. 659.

Typical in all forms examined.

##### M. ILIO-TROCHANTERICUS MEDIUS (Il. troc. med.)

*M. ilio-trochantericus medius*—Fisher, 1946, p. 661.

A distinct and separate muscle in the *Cathartidae*; fused with the *M. iliotrochantericus anterior* in *Sagittarius* and all other falconiform birds examined.

##### M. GLUTAEUS MEDIUS ET MINIMUS (Glut. med. et min.)

*M. piriformis*—Fisher, 1946, p. 658.

Typical in all forms examined.

##### M. ILIACUS (Iliacus)

*M. psoas*—Fisher, 1946, p. 670.

Typical in all forms examined.

##### M. AMBIENS (Ambiens)

*M. Ambiens*—Fisher, 1946, p. 669.

Typical in all forms examined except *Falco* in which the tendon of insertion passes lateral to the tendon of the *M. biceps femoris*. So far as known *Falco* is apparently unique in this respect among all birds. Whether this condition exists in other genera of Falconidae is yet to be determined.

##### M. SARTORIUS (Sar.)

*M. extensor ilio-tibialis anterior*—Fisher, 1946, p. 658.

Typical in all forms examined.

##### M. ILIO-TIBIALIS (Il. tib.)

*M. extensor ilio-tibialis lateralis*—Fisher, 1946, p. 657.

Arises only from the acetabular and preacetabular ilium in *Sagittarius*, the Acci-

pitridae, *Pandion* and *Falco*. In these the belly does not overlap the *M. biceps femoris*. The origin in the Cathartidae is from the dorsal ridge of almost the entire length of the ilium, the belly, accordingly, overlapping most of the *M. biceps femoris*.

*Sagittarius* is most peculiar in that the *M. ilio-tibialis* has two separate bellies. The anterior of these arises fleshy from a small area on the pre-acetabular ilium just lateral to the posterior edge of the origin of the *M. sartorius* and inserts by an aponeurotic sheet on the anterior side of the knee in common with the rest of the ilio-tibialis muscle. The posterior belly has a narrow tendinous origin mainly from the acetabular ilium and becomes much broader distally.

M. FEMORI-TIBIALIS EXTERNUS (Fem. tib. ext.)

*M. vastus lateralis*—Fisher, 1946, p. 661.

This is a separate muscle in *Sagittarius* but in the Cathartidae and all other falconiform birds examined it is intimately fused with the *M. femori-tibialis medius*.

M. FEMORI-TIBIALIS MEDIUS (Fem. tib. med.)

*M. vastus medialis*—Fisher, 1946, p. 661.

No significant variations noted.

M. FEMORI-TIBIALIS INTERNUS (Fem. tib. int.)

*M. femorotibialis internus*—Fisher, 1946, p. 670.

No significant variations noted.

M. PIRIFORMIS (Pirif.)

*M. caudofemoralis*—Fisher, 1946, p. 665.

In *Sagittarius* the Pars ilio-femoralis is present and the Pars caudi-femoralis absent. *Cathartes*, *Coragyps* and all other falconiform birds examined show just the opposite condition, the Pars ilio-femoralis being absent and the Pars caudi-femoralis present.

According to Fisher (1946, p. 666) the entire muscle is absent in *Gymnogyps*, *Sarcoramphus*, and *Vultur*. In *Pandion* the Pars caudi-femoralis inserts on the femur by an especially long and narrow tendon.

M. SEMITENDINOSUS (Semit.)

*M. flexor cruris lateralis*—Fisher, 1946, p. 662.

Both the semitendinosus proper and its accessory belly are present and well developed in *Sagittarius* and the Cathartidae. The entire muscle is absent in all other forms studied. Fisher (1946, p. 663) considers a portion of the Pars media *M. gastrocnemii* as belonging to this muscle, calling it the distal accessory head.

M. SEMIMEMBRANOSUS (Semim.)

*M. flexor cruris medialis*—Fisher, 1946, p. 665.

*Sagittarius* is peculiar among all the birds I have examined in that the insertion of this muscle extends up to the extreme proximal end of the Caput tibiae. In the genus *Falco* the *M. semimembranosus* consists of two distinct bellies which insert together (Hudson, 1937, p. 24). No other significant variations were observed in the falconiform birds studied.

M. BICEPS FEMORIS (Bic. fem.)

*M. extensor ilio-fibularis*—Fisher, 1946, p. 662.

Typical in all forms examined.

M. ISCHIO-FEMORALIS (Isch. fem.)

*M. flexor ischiofemoralis*—Fisher, 1946, p. 666.

Typical in all forms examined.

M. OBTURATOR INTERNUS (Obt. int.)

Typical in the Cathartidae, Accipitridae, *Pandion* and *Falco*. In *Sagittarius* the origin extends laterally onto the ventral surface of the postero-lateral part of the ilium, similar to the condition in *Fulica*, *Porzana* and *Colinus* (Hudson, 1937, p. 27).

## M. OBTURATOR EXTERNUS (Obt. ext.)

In the specimen of *Pandion* available this muscle appears to consist of a single belly with one area of insertion. It is made up of two bellies with separate areas of insertion on the femur in all other falconiform birds studied.

## M. ADDUCTOR LONGUS ET BREVIS (Add. long.)

Fisher (1946, p. 667-8) calls the Pars externa of this muscle the *M. adductor superficialis*; the Pars interna the *M. adductor profundus*.

The two parts are clearly divisible in all forms examined. The Pars interna inserts mainly as a thin aponeurotic sheet except in *Pandion* in which both parts have fleshy insertions.

## M. TIBIALIS ANTERIOR (Tib. ant.)

In the Accipitridae, *Pandion* and *Falco* the origin of the tibial head includes a long narrow line down the medial side of the tibial shaft. There is no connection with the shaft of the tibia in the Cathartidae and *Sagittarius*.

In *Sagittarius*, the Cathartidae and *Pandion* there is no accessory tendon of insertion. Species of Accipitridae examined have a small accessory tendon of insertion on the medial side. *Falco* has two such accessory tendons, one medial, the other lateral (Hudson, 1937, p. 30).

## M. EXTENSOR DIGITORUM LONGUS (Ext. dig. I.)

No important modifications were noted in this muscle. The proximal tarsal loop under which the tendon passes is fibrous in all forms examined except *Pandion* in which it is bony.

## M. PERONEAEUS LONGUS (Per. long.)

*M. peroneus longus*—Fisher, 1946, p. 674.

The belly is broad in *Sagittarius* and the Cathartidae; narrow in *Falco* and the Accipitridae. The muscle is absent in *Pandion* as previously indicated by Gadow (1891, p. 181).

## M. PERONEAEUS BREVIS (Per. brev.)

*M. peroneus brevis*—Fisher, 1946, p. 683.

In *Sagittarius* the belly is broad distally, the origin extending onto the anterior side of the tibio-tarsus for a considerable distance. The muscle is typical in all other falconiform birds studied.

## M. GASTROCNEMIUS (Gas.)

The proximal end of the Pars interna extends around the front of the knee in *Sagittarius* and the Cathartidae. This is not the case in the Accipitridae, *Pandion* and *Falco*. The Pars media is typical in all forms examined except the Cathartidae. In these it is peculiar in consisting of two quite distinct parts, the outer of which arises by a narrow tendon from the Regio intercondyloidea. This double nature of the Pars media was not described for *Cathartes* by Hudson (1937). The Pars externa shows no important modifications.

The entire muscle forms a broad, flat tendon toward the lower end of the shank in the Cathartidae, *Sagittarius*, *Pandion* and *Falco*. In the Accipitridae there are strong medial and lateral tendons, connected by thin fascia, and these unite above the tibial cartilage.

## M. PLANTARIS (Plan.)

Absent in *Sagittarius*, *Pandion* and the Accipitridae; typical in the Cathartidae; strongly developed in *Falco*, the belly reaching almost to the tibial cartilage, a condition apparently not known to occur in any other group of birds.

## M. FLEXOR PERFORATUS DIGITI II (Flex. per. d. II)

The tendon of insertion is clearly perforated by the deep flexors in *Sagittarius*, less clearly so in *Cathartes* and *Coragyps*; the insertion is not perforated in the Accipitridae, *Pandion* and *Falco*.

## M. FLEXOR PERFORATUS DIGITI III (Flex. per. d. III)

One-headed in *Sagittarius* and *Pandion*; a vague division into two heads in *Cath-*

artes and *Coragyps*; 2-headed in *Falco* and the Accipitridae, the anterior head from the other superficial flexors about midway the shank, the posterior head from the Regio intercondyloidea. The latter head in the Accipitridae is in common with the M. flexor perforatus digiti II and M. flexor perforatus digiti IV. In *Falco* this femoral head arises by a long independent tendon.

A strong vinculum connects the tendon of this muscle with that of the M. flexor perforans et perforatus digiti III, near the lower end of the tarso-metatarsus in *Sagittarius* and the Cathartidae. There is no such connection in the Accipitridae, *Pandion* and *Falco*.

The tendon of insertion is clearly perforated by the deep flexors in all forms examined with the exception of *Pandion* in which the insertion is entirely on the medial side of the proximal phalanx.

Fisher (1946, p. 679) states that in *Vultur* there is a vinculum connecting the tendon of the M. flexor perforatus digiti III with the tendon of the M. flexor perforatus digiti IV, at the middle of the tarsal length. If this is true *Vultur* is apparently unique among all birds in which the leg musculature has been studied.

#### M. FLEXOR PERFORATUS DIGITI IV (Flex. per. d. IV)

Two-headed in *Sagittarius* and the Accipitridae, one from the Regio intercondyloidea in common with other "perforatus" muscles, the other from the Caput fibulae, the tendon of the M. biceps femoris passing between them. The muscle is single in the Cathartidae, *Pandion* and *Falco*.

The tendon of insertion is divided into three short branches near the base of the fourth toe in *Sagittarius* and the Cathartidae. The insertion is single in *Pandion* and not clearly divided in *Falco* and the Accipitridae.

#### M. FLEXOR PERFORANS ET PERFORATUS DIGITI II (F. p. et p. d. II)

The only important modification found in this muscle was in *Pandion* in which the tendon of insertion fuses completely with the tendon of the M. flexor perforatus digiti II opposite the tibial cartilage. This apparently unique condition in *Pandion* has been described by Gadow (1891, p. 192).

#### M. FLEXOR PERFORANS ET PERFORATUS DIGITI III (F. p. et p. d. III)

The origin is partly from the shaft of the fibula in the Cathartidae and *Falco*, but in *Sagittarius*, *Pandion* and the Accipitridae there is no such attachment.

#### M. FLEXOR DIGITORUM LONGUS (F. dig. I.)

*Pandion* and the Accipitridae are peculiar in having much of the belly visible superficially on the lateral side of the shank. In *Sagittarius*, the Cathartidae and *Falco* the belly is deeply buried among the other flexor muscles, the condition found in most birds.

At the level of the M. popliteus the belly is more or less distinctly notched for the passage of large blood vessels and nerves. This is most clearly seen in *Sagittarius*, *Pandion* and the Accipitridae. *Buteo* and *Aquila* have a small lateral head of origin coming from the Caput fibulae and anterior tibial crest, separated from the main head by the tendon of the M. biceps femoris.

Below the middle of the tarso-metatarsus the tendon of the M. flexor digitorum longus is connected with that of the M. flexor hallucis longus by a strong vinculum in *Sagittarius*, *Pandion* and the Accipitridae and *Falco*. In these birds the tendon of the M. flexor hallucis longus contributes extensively to the formation of the branch serving the second toe. This is Gadow's Type III (1891, p. 195). In the Cathartidae the two deep flexor tendons fuse about midway the tarsometatarsus, or above, the common tendon then giving off four branches below, one to each toe; *Pandion* is similar. This condition in the American vultures and *Pandion* represents Gadow's Type V (1891, p. 195).

*Falco* is the only falconiform bird examined in which the tendon of the F. dig. I. is ossified in the region of the tarso-metatarsus.

#### M. FLEXOR HALLUCIS LONGUS (F. hal. I.)

Belly very large and powerful in *Sagittarius*, the Accipitridae, *Pandion* and *Falco*; comparatively weak and typical in the Cathartidae. At the extreme proximal end

there is more or less of a division into two short heads, most pronounced in *Sagittarius*, the Accipitridae, *Pandion* and *Falco*; faintly indicated in the Cathartidae. The area of origin on the femur is quite extensive in *Sagittarius*, extending up the femoral shaft more than half an inch above the proximal arm of the biceps loop; not extending above this loop in the other forms examined.

In *Sagittarius*, *Falco* and the Accipitridae the tendon of the F. hal. 1. lies directly behind that of the F. dig. 1. at the heel; it is postero-lateral in the Cathartidae and *Pandion*. The tendon of the F. hal. 1. is ossified in the region of the tarso-metatarsus in *Falco*; ossified for a short distance above the toe branches in *Pandion*; not ossified at all in other forms studied.

#### M. POPLITEUS (Pop.)

This muscle shows considerable variation in size, being strongest in *Sagittarius* and the Accipitridae and weakest in *Pandion*. It is well-developed and typical in the Cathartidae.

#### M. EXTENSOR HALLUCIS LONGUS (Ext. hal. 1.)

Slender and single in *Sagittarius* and the Cathartidae, the origin from most of the tarsal length. The belly is strong and two-headed in the Accipitridae, *Pandion* and *Falco*, the tendon of the M. tibialis anterior passing between the two parts. *Pandion* has a small fleshy slip from the outer head that arises on the tendon of the M. tibialis anterior. In the Accipitridae the medial head is very powerful and is deeply grooved on the anterior surface, forming a fleshy sheath about the tendon of the M. extensor digitorum longus. In *Pandion* and *Falco* the inner head is not so well-developed and does not form such a sheath. The origin of the M. extensor hallucis longus in the Accipitridae, *Pandion* and *Falco* is restricted to the proximal end of the tarso-metatarsus, mainly or entirely above the insertion of the M. tibialis anterior.

#### M. EXTENSOR PROPRIUS DIGITI III AND M. EXTENSOR BREVIS DIGITI III (Ext. pro. d. III and Ext. brev. d. III)

In the specimen of *Sagittarius* at hand no trace was found of a short extensor to the third digit. There is a single rudimentary extensor to the third toe in *Cathartes*, *Coragyps* and *Falco*, restricted to about the distal one-fifth of the tarso-metatarsus. Fisher (1946, p. 688) states that two short extensors to the third toe are present in the Cathartidae, one of which arises near the insertion of the M. tibialis anterior. This requires confirmation.

There is a single short extensor to the third toe in the Accipitridae. This is well-developed in *Aquila* and *Buteo*, extending up to or above the insertion of the M. tibialis anterior; much shorter and weaker in *Circus* and *Accipiter*.

*Pandion* is unique among all the birds I have examined in having two well-developed short extensors to the third toe. The large medial muscle extends up to the point of insertion of the M. tibialis anterior and apparently represents Gadow's M. extensor proprius digiti III. The small lateral muscle is much shorter and may represent Gadow's M. extensor brevis digiti III, although his descriptions of these two muscles (1891, pp. 199-200) are confusing.

#### M. EXTENSOR BREVIS DIGITI IV (Ext. brev. d. IV)

Short and weak in *Sagittarius*, confined to about the distal one-third of the tarso-metatarsus. Well-developed and typical in the Cathartidae and *Pandion*, the origin fleshy from most of the length of the tarso-metatarsus. In the Accipitridae and *Falco* the belly is confined to the proximal half or less of the tarso-metatarsus, the tendon long.

#### M. ABDUCTOR DIGITI II (Abd. dig. II)

Short and stout in *Sagittarius*, confined to about the distal one-eighth of the tarso-metatarsus and arising almost wholly from Metatarsale I. Limited to about the distal one-third of the tarso-metatarsus in the Cathartidae, to about the distal one-half in *Pandion*, in both of these arising from Metatarsale I and II. Very weak in *Falco*, confined to about the distal one-fourth of the tarso-metatarsus, the origin from Metatarsale I and II. The Accipitridae are peculiar in having the M abductor digiti II



extend almost the entire length of the tarso-metatarsus. In these birds the proximal end of the belly is usually divided by the tendon of insertion of the *M. tibialis anterior*.

*M. FLEXOR HALLUCIS BREVIS* (F. hal. brev.)

Origin from almost the entire length of the tarso-metatarsus in the Cathartidae, the tendon very short. Belly confined to about the proximal one-third of the tarso-metatarsus in *Sagittarius*, the tendon long; very strong in *Pandion*, the belly wide and triangular, the tendon about as long as the belly; belly confined to about the proximal two-thirds of the tarso-metatarsus in *Falco*; belly confined to about the proximal one-third to one-half of the tarso-metatarsus in the Accipitridae.

The tendon in the Accipitridae is very peculiar in being double, with a wider medial tendon and a narrower lateral tendon. These unite at the point of insertion.

In all of the Falconiform birds examined, with the exception of the vultures, the tendon of the *M. flexor hallucis brevis* is not perforated by the branch from the deep flexor. The tendon of insertion is clearly perforated in the Cathartidae.

*M. ADDUCTOR DIGITI II* (Add. d. II)

In *Sagittarius*, *Falco* and the Accipitridae the belly is very weak and arises near the proximal end of the tarso-metatarsus, the tendon very long and slender; very similar in the Cathartidae but the muscle is somewhat stronger; similar but still stronger in *Pandion*, the belly reaching down below the middle of the tarso-metatarsus.

*M. LUMBRICALIS* (Lumb.)

This muscle is present but very weakly developed in all forms examined with the exception of *Pandion*, in which it consists of a thin but very broad fleshy belly.

*M. ABDUCTOR DIGITI IV* (Abd. d. IV)

Short, confined to about the distal fourth of the tarso-metatarsus in *Sagittarius*; origin from almost the entire length of the tarso-metatarsus in the Cathartidae and *Aquila*; belly confined to about the proximal two-thirds of the tarso-metatarsus in *Pandion*, the proximal one-third or one-half in *Falco*, *Buteo*, *Accipiter*, and *Circus*.

In the Cathartidae and Accipitridae and *Sagittarius* the insertion is on the lateral side of Phalanx I; the outer side of Phalanx II in *Pandion* and *Falco*.

The entire muscle is most strongly developed in *Pandion* where it functions in abducting and reversing the fourth toe.

*M. ADDUCTOR DIGITI IV* (Add. d. IV)

No such muscle observed in the specimens examined.

MODIFICATIONS OF THE MUSCLES OF THE PELVIC LIMB IN THE  
HIGHER GROUPS OF FALCONIFORM BIRDS

AMERICAN VULTURES, FAMILY CATHARTIDAE

Based on.—*Cathartes aura* (2); *Coragyps atratus* (2); also in part on the work of Fisher (1946) who studied specimens of *Gymnogyps californianus*, *Vultur gryphus*, *Coragyps atratus* and *Cathartes aura*.

Myological formula.—*Cathartes* and *Coragyps*: ACDXYAmV; *Gymnogyps*, *Vultur* and *Sarcoramphus*: CDXYAmV.

Muscles absent.—Pirif., Pars ilio-femoralis. Both parts of Pirif. absent in *Gymnogyps*, *Vultur* and *Sarcoramphus* (Fisher, 1946, p. 666).

Muscles rudimentary.—Ext. pro. d. III; lumbricalis.

Deep flexor tendons.—Gadow's Type V. The two tendons fuse completely; four branches below, the smallest to the hallux.

Hypotarsus.—No flexor tendons pass through bony canals.

Outstanding peculiarities.—Pars caudifemoralis of Pirif. absent in *Gymnogyps*, *Vultur* and *Sarcoramphus* (present in *Cathartes* and *Coragyps*); Pars media of Gas. two headed; Flex. per. d. IV with trifurcated insertion.

Other significant modifications.—Il. troc. med. a separate muscle; Il. tib. with post-acetabular portion well developed, covering most of the Bic. fem.; Fem. tib. ext. fused

with the Fem. tib. med.; origin of Obt. int. typical, not including postero-lateral ilium; Obt. ext. consists of two bellies with separate points of insertion; Add. long divided into a Pars externa and Pars interna; both parts of Semit. present; Tib. ant. without an accessory tendon of insertion; belly of Per. long very broad; Gas. with a single tendon of insertion; Pars interna of Gas. extends around the front of knee; a vinculum connects the tendon of the Flex. per d. III with that of the F. p. et p. d. III; Flex. per. d. IV one-headed; origin of the F. p. et p. d. III includes fibular shaft; belly of F. dig. I. not visible superficially; Popliteus present and typical; Ext. hal. I. single and slender, the origin from most of the length of the tarso-metatarsus; Ext. brev. d. IV typical, arising fleshy from most of the length of the tarso-metatarsus; Abd. dig. II limited to about the distal one-third of the tarso-metatarsus, arising from Metatarsale I and II; F. hal. brev. single, arising from most of the length of the tarso-metatarsus, the tendon of insertion clearly perforated by the deep flexor; Add. d. II arises near the proximal end of the tarso-metatarsus, the tendon very long; Abd. d. IV arises from almost the entire length of the tarso-metatarsus, the insertion on the lateral side of the base of the proximal phalanx; no tendons ossified.

*The More Important Inter-generic Differences Noted.*—*M. ilio-tibialis*. Covers almost the entire belly of the Bic. fem. in *Coragyps*; a small portion of the proximal end of the Bic. fem. is visible superficially in *Cathartes*.

*M. piriformis*. Pars caudi-femoralis present in *Cathartes* and *Coragyps*; absent in *Gymnogyps*, *Sarcoramphus* and *Vultur* (Fisher, 1946, p. 666). In *Cathartes* the tendon of insertion on the femur is about four millimeters long; about fifteen millimeters long in *Coragyps*.

*M. adductor longus et brevis*. Pars externa much stronger than Pars interna in *Cathartes*; the two parts more nearly the same size in *Coragyps*.

From the foregoing account it is apparent that the Cathartid vultures are very generalized in the musculature of the pelvic limb, showing very few outstanding peculiarities. It further suggests that the Family Cathartidae is a fairly homogeneous group with few important inter-generic modifications.

#### SECRETARY BIRD, FAMILY SAGITTARIIDAE

*Based on.*—*Sagittarius serpentarius* (1).

*Miological formula.*—BDXYAmV.

*Muscles absent.*—II. troc. med. not present as a separate muscle—fused with the II. troc. ant.; Pirif., Pars caudi-femoralis; Plantaris; Ext. pro. d. III (?).

*Muscles rudimentary.*—Lumbricalis.

*Deep flexor tendons.*—Gadow's Type III, but tendon to index digit no larger than that to medius.

*Hypotarsus.*—No flexor tendons pass through bony canals.

*Outstanding peculiarities.*—Belly of II. tib. divided proximally; Pars caudi-femoralis of Pirif. absent; insertion of Semim. extends up to extreme proximal end of Caput tibiae; origin of Obt. int. extends laterally onto the ventral surface of the postero-lateral part of the ilium; belly of Per. brev. broad distally, the origin extending onto the anterior surface of the tibio-tarsus; Plantaris absent; tendon of Flex. per. d. IV trifurcated; origin of the F. hal. I. extends up the femoral shaft more than half an inch above the proximal arm of the biceps loop; tendon of the F. hal. I. lies directly behind that of the F. dig. I. at the heel; Ext. brev. d. IV confined to about the distal one-third of the tarso-metatarsus; Abd. d. IV very short, confined to about the distal fourth of the long tarso-metatarsus.

*Other significant modifications.*—II. troc. med. fused with the II. troc. ant.; II. tib. not connected with post-acetabular ilium; Fem. tib. ext. a separate muscle; both parts of Semit. present; Obt. ext. consists of two bellies with separate points of insertion; Add. long. divided into a Pars externa and Pars interna; Tib. ant. without an accessory tendon of insertion; belly of Per. long. very broad; Pars interna of Gas. extends around the front of knee; Flex. per. d. III one-headed; Flex. per. d. IV two-headed, the tendon of the Bic. fem. passing between them; belly of F. p. et p. d. III not connected with fibular shaft; Popliteus strongly developed; belly of the Ext. hal. I. single and slender, arising from most of the length of the tarso-metatarsus; Abd. dig. II very short and arising mainly from Metatarsale I; tendon of the F. hal. brev. single and not

perforated by the deep flexor, the belly confined to about the proximal third of the tarso-metatarsus; Add. d. II arises near the proximal end of the tarso-metatarsus, the tendon very long; no tendons ossified.

It is well known that the foot of *Sagittarius* is adapted for seizing prey, although much less strongly modified for this purpose than the condition found in many hawks and falcons, in which both the shank muscles operating the toes and the intrinsic muscles of the foot are much more powerfully developed.

In viewing the musculature of the shank as a whole it is seen that the entire muscle mass is confined to little more than the proximal half of the tibio-tarsus, correlated with the highly terrestrial habits of *Sagittarius*. This is in striking contrast to the situation in the vultures, hawks and falcons in which the fleshy bellies of many muscles extend almost to the inter-tarsal joint.

No doubt a Buteonid hawk of comparable size with *Sagittarius* could capture and fly away with an animal of much greater bulk than could the latter.

#### OTHER FALCONIFORM BIRDS

##### FAMILIES ACCIPITRIDAE, PANDIONIDAE AND FALCONIDAE

Based on.—Family Accipitridae: *Accipiter cooperii* (1), *Buteo jamaicensis* (2), *Buteo swainsoni* (1), *Aquila chrysaetos* (1), *Circus cyaneus* (1). Family Pandionidae: *Pandion haliaetus* (1). Family Falconidae: *Falco sparverius* (2), *Falco columbarius* (1), *Falco peregrinus* (1) (Shank and foot only).

Myological formula.—ADAm.

Muscles absent.—Il. troc. med not present as a separate muscle—fused with the Il. troc. ant.; Pirif., Pars ilio-femoralis; Semit. (both parts); Plantaris in *Pandion* and Accipitridae (present in *Falco*); Per long. (*Pandion* only).

Muscles rudimentary.—Ext. pro. d. III (*Falco* only); Lumbricalis (except *Pandion*).

Deep flexor tendons.—Gadow's Type III in *Falco* and the Accipitridae; Type V in *Pandion*.

Hypotarsus.—No flexor tendons traverse bony canals in *Falco* and the Accipitridae; tendons of the F. hal. I. and F. dig. I. pass through a bony canal in *Pandion*.

Outstanding peculiarities.—Tendon of *Ambiens* passes lateral to that of the Bic. fem. (*Falco* only). Entire Semit. absent; belly of the Semim. divided lengthwise (*Falco* only); tibial head of Tib. ant. arises from the anterior tibial crest and a long line down the shaft of the tibia; Plantaris either absent (*Pandion* and Accipitridae) or unusually powerful (*Falco*); tendon of the F. p. et p. d. II fuses completely with that of the Flex. per. d. II opposite the tibial cartilage (*Pandion* only); belly of F. dig. I. extensively visible superficially on lateral side of shank in *Pandion* and the Accipitridae (proximal portion covered by other muscles in *Falco*); tendon of F. hal. I. lies behind that of the F. dig. I. at the heel in *Falco* and the Accipitridae (it is postero-lateral in *Pandion*) Ext. hal. I. two-headed and very powerful; two distinct short extensors to the third toe (*Pandion* only).

Other significant modifications.—Il. troc. med. fused with the Il. troc. ant.; Il. tib. not connected with post-acetabular ilium; Fem. tib. ext. fused with Fem. tib. med.; Add. long. divided into a Pars externa and Pars interna; Per. long. absent in *Pandion*, the belly very narrow in *Falco* and the Accipitridae; Tib. ant. with accessory tendon of insertion in *Falco* and the Accipitridae (no accessory tendon in *Pandion*); Pars interna of Gas. does not extend around the front of knee; tendon of Flex. per. d. II not perforated by the deep flexors; Flex. per. d. III one-headed in *Pandion*, two-headed in *Falco* and the Accipitridae; Flex. per. d. IV one-headed in *Pandion* and *Falco*, two-headed in Accipitridae; origin of F. p. et p. d. III not connected with fibular shaft in *Pandion* and the Accipitridae, connected with fibular shaft in *Falco*; Popliteus present; Ext. pro. d. III vestigial in *Falco*, fairly well developed in the Accipitridae; Abd. dig. II very long in the Accipitridae, extending almost the entire length of the tarso-metatarsus, much shorter in *Pandion* and *Falco*; tendon of F. hal. brev. not perforated by the deep flexor; belly of Add. d. II confined to about the proximal half or less of the tarso-metatarsus, the tendon long; tendons of F. dig. I. and F. hal. I. ossified in region of tarso-metatarsus in *Falco*; tendon of F. hal. I. ossified for a short distance above toe branches in *Pandion*; no ossified tendons in the Accipitridae.

SUMMARY OF DIFFERENCES NOTED BETWEEN PANDION, FALCO AND THE ACCIPITRIDAE

	<i>Pandion</i>	<i>Falco</i>	Accipitridae
Ambiens	Typical	Tendon passes <i>lateral</i> to tendon of Bic. fem.	Typical.
Pirif.	Par. caudi-femoralis inserts by a long narrow tendon.	Insertion typical.	Insertion typical.
Semim.	Typical	Belly divided lengthwise.	Typical.
Obt. ext.	Belly apparently single.	Two bellies with separate points of insertion.	Two bellies with separate points of insertion.
Tib. ant.	No accessory tendon of insertion.	Two small accessory tendons of insertion.	One small accessory tendon of insertion.
Per. long.	Absent.	Present.	Present.
Plantaris	Absent.	Present.	Absent.
Flex. per. d. III	One-headed; tendon of insertion not clearly perforated by the deep flexor.	Two-headed; medial head arises alone by a long, narrow tendon from the Regio intercondyloidea; tendon of insertion perforated.	Two-headed; medial head arises fleshy from the Regio intercondyloidea in common with the posterior head of the Flex. per. d. IV; tendon of insertion perforated.
Flex. per. d. IV	One-headed; no "perforatus" flexors pass medially to the tendon of the Bic. fem; these muscles therefore have no connection with the Regio inter-condyloidea but arise entirely from the anterior tibial crest, Caput fibulae and external condyle.	One-headed; tendon of the medial head of the Flex. per. d. III is the only "perforatus" muscle passing medially to the tendon of the Bic. fem. and is, therefore, the only one of these "perforatus" muscles arising from the Regio inter-condyloidea.	Two-headed, the tendon of the Bic. fem. passing between them; common heads of the Flex. per. d. II, III and IV pass medially to the tendon of the Bic. fem. and arise from the Regio. intercondyloidea.
F. p. et p. d. II	Tendon fuses with the Flex. per. d. II at heel.	Tendon remains separate.	Tendon remains separate.

	<i>Pandion</i>	<i>Falco</i>	<i>Accipitridae</i>
F. p. et p. d. III.	No fleshy connection with fibular shaft.	Origin partly from fibular shaft.	No fleshy connection with fibular shaft.
F. dig. I.	Much of belly visible superficially on lateral side of shank.	Belly concealed by superficial muscles.	Much of belly visible superficially on lateral side of shank.
Deep flexors	Gadow's Type V.	Gadow's Type III.	Gadow's Type III.
Ext. hal. I.	Inner head does not form a sheath about the tendon of the Ext. dig. I.; outer head with a fleshy slip from the tendon of the Tib. ant.	Inner head does not form a sheath about the tendon of the Ext. dig. I.; no fleshy slip from the Tib. ant.	Medial head forms a sheath about the tendon of the Ext. dig. I.; no fleshy slip from the Tib. ant.
Ext. pro. d. III & Ext. brev. d. III.	Two well-developed short extensors to the third toe.	One vestigial short extensor to the third toe.	One fairly well-developed short extensor to the third toe.
Ext. brev. d. IV.	Fleshy belly extends almost to inter-metatarsal canal.	Belly shorter, the tendon correspondingly longer.	Belly shorter, the tendon correspondingly longer.
Abd. dig. II.	Short and typical.	Short and typical.	Unusually long, extending almost the entire length of tarso-metatarsus.
F. hal. brev.	One tendon.	One tendon.	Two tendons.
Add. d. II.	Much stronger, the belly extending more than halfway down tarso-metatarsus.	Much weaker, the belly very short, the tendon correspondingly long.	Still weaker, the belly very short, the tendon correspondingly long.
Abd. d. IV.	Inserts on outer side of Phalanx II.	Inserts on outer side of Phalanx II.	Inserts on outer side of Phalanx I.
Hypotarsus.	Tendons of F. dig. I. and F. hal. I. pass through a bony canal.	No flexors pass through complete bony canals.	No flexors pass through complete bony canals.
Proximal tarsal loop for tendon of Ext. dig. I.	Ossified.	Tendinous.	Tendinous.
Ossified tendons.	F. hal. I. in foot.	F. dig. I. and F. hal. I. in foot.	None.

APPARENT DIFFERENCES BETWEEN SEVERAL GENERA OF ACCIPITRIDAE

	<i>Accipiter</i>	<i>Buteo</i>	<i>Aquila</i>	<i>Circus</i>
Sartorius	Inserts by a fairly narrow tendon.	Broader and partly fleshy at insertion.	Broader and partly fleshy at insertion.	Inserts by a very narrow tendon.
Fem. tib. int.	Lengthwise division only slightly indicated.	Belly with a well marked lengthwise division.	Belly with a well marked lengthwise division proximally.	Lengthwise division only slightly indicated distally.
Pars. caudi-femoralis of Pirif.	Insertion entirely tendinous.	Insertion entirely tendinous.	Insertion entirely tendinous.	Insertion broad and entirely fleshy.
Semim.	Inserts by a short and fairly narrow tendon.	Inserts by a short and fairly narrow tendon.	Inserts by a broader tendon.	Inserts by a long narrow tendon.
Gastrocnemius	Medial and lateral tendons distinct proximally, connected by only the weakest fascia.	Medial and lateral tendons connected by somewhat heavier fascia.	Medial and lateral tendons connected by heavier fascia.	Medial and lateral tendons distinct proximally, connected by only the weakest fascia.
F. dig. I.	No prominent lateral head connected with anterior tibial crest.	A distinct lateral head connected with anterior tibial crest.	A distinct lateral head connected with anterior tibial crest.	No prominent lateral head connected with anterior tibial crest.

As seen in the foregoing comparisons the musculature of the pelvic limb in the Accipitridae, *Falco* and *Pandion* shows many important differences. After a study has been made of all living genera many of these modifications will probably be recognized as family characteristics.

The inter-generic modifications noted within the Family Accipitridae are slight. In addition to the differences listed the total musculature of the pelvic limb in *Buteo* and *Aquila* appears much more powerful than that of *Accipiter* and *Circus* which seem almost weak in comparison.

#### COMPARISON OF CATHARTIDAE AND SAGITTARIUS

*Important similarities.*—Glut. med. et min. present; Ambiens present; Pars caudi-femoralis of Pirif. absent in *Gymnogyps*, *Sarcorampus*, *Vultur* (Fisher, 1946, p. 666) and *Sagittarius*. Present in *Cathartes* and *Coragyps*; both parts of Semit. present; Obt. ext. consists of two bellies with separate areas of insertion; Add. long. divided into a Pars externa and Pars interna; Tib. ant. without an accessory tendon of insertion; belly of Per. long. very broad; tendon of Gas. single, the Pars interna extending around the front of knee; a strong vinculum connects the tendon of the Flex. per. d. III with that of the F. p. et p. d. III near the lower end of the tarso-metatarsus; tendon of the Flex. per. d. IV trifurcated at insertion; belly of F. dig. I. not visible superficially; Ext. hal. I. slender and single, fleshy all the way to base of hallux; Add. d. II arises near the proximal end of the tarso-metatarsus, the tendon long; no flexor tendons pass through bony canals.

#### Important differences

Cathartidae	Sagittarius
Il. troc. ant. and med. separate muscles.	Il. troc. ant. and med. fused into one muscle.
Il. tib. single, connected with postacetabular ilium.	Belly of Il. tib. divided proximally, not connected with post-acetabular ilium.
Fem. tib. ext. not present as a separate muscle.	Fem. tib. ext. present as a separate muscle.
Pars caudi-femoralis of Pirif. present in <i>Cathartes</i> and <i>Coragyps</i> (absent in <i>Gymnogyps</i> , <i>Vultur</i> and <i>Sarcorampus</i> —Fisher, 1946, p. 666).	Pars caudi-femoralis of Pirif. absent.
Insertion of Semim. typical.	Insertion of Semim. unusually high upon Caput tibiae.
Origin of Obt. int. typical.	Origin of Obt. int. extends laterally onto the ventral surface of the post-acetabular ilium.
Pars media of Gas. two-headed.	Pars media of Gas. typical (single).
Per. brev. typical.	Per. brev. very broad distally, the origin extending onto the anterior side of the tibio-tarsus.
Plantaris present.	Plantaris absent.
Belly of Flex. per. d. IV single.	Flex. per. d. IV two-headed.
Origin of F. p. et p. d. III connected with fibular shaft.	F. p. et p. d. III not connected with fibular shaft.
Deep flexor tendons Type V.	Deep flexor tendons Type III.



## Cathartidae

*Pandion*

Belly of F. hal. 1. weak.

Belly of F. hal. 1. very large and powerful.

Origin of F. hal. 1. does not extend up femur above proximal arm of biceps loop.

Origin of F. hal. 1. extends up femur above proximal arm of biceps loop.

Tendon of F. hal. 1. is postero-lateral at heel.

Tendon of F. hal. 1. lies directly behind the F. dig. 1. at heel.

Ext. pro. d. III present.

Ext. pro. d. III apparently absent.

Ext. brev. d. IV long, extending along most of the length of tarso-metatarsus.

Ext. brev. d. IV short, confined to about distal third of tarso-metatarsus.

Abd. dig. II limited to about the distal one-third of tarso-metatarsus.

Abd. dig. II limited to about the distal one-eighth of tarso-metatarsus.

Belly of F. hal. brev. extends all the way to base of hallux.

Belly of F. hal. brev. confined to about the proximal one-third of tarso-metatarsus.

Tendon of F. hal. brev. perforated by the deep flexor tendon.

Tendon of F. hal. brev. not perforated.

Abd. d. IV typical, extending along most of the length of the tarso-metatarsus.

Abd. d. IV short, confined to about the distal fourth of tarso-metatarsus.

The similarities noted between the Cathartidae and *Sagittarius* are hardly more extensive than could be expected in a comparison of birds in almost any two orders selected at random. The differences, on the other hand are greater than could be expected between two birds belonging to the same order.

The Cathartidae are clearly more generalized than *Sagittarius*, showing but few unusual peculiarities.

COMPARISON OF SAGITTARIUS AND TYPICAL FALCONES  
(Accipitridae, Pandionidae and Falconidae)

*Important similarities.*—Il. troc. med. fused with Il. troc. ant.; Glut. med. et min. present; Ambiens present; post-acetabular portion of Il. tib. absent; Add. long, divided into a Pars externa and Pars interna; Pars media of Gas. single; Plantaris absent (except *Falco*); deep flexor tendons Type III (except *Pandion*); belly of F. hal. 1. large and powerful; tendon of F. hal. 1. lies directly behind that of the F. dig. 1. at heel (except *Pandion*); belly of F. hal. brev. confined to proximal two-thirds or less of tarso-metatarsus; tendon of F. hal. brev. not perforated by the deep flexor; Add. d. II arises from the proximal portion of the tarso-metatarsus, the tendon long; no flexor tendons pass through complete bony canals (except *Pandion*).

*Important differences**Sagittarius*

## Typical Falcones

Il. tib. divided into two bellies proximally.

Il. tib. single.

Fem. tib. ext. present as a separate muscle.

Fem. tib. ext. fused with the Fem. tib. med.

Pars ilio-femoralis of Pirif. present.

Pars ilio-femoralis of Pirif. absent.

Pars caudi-femoralis of Pirif. absent.

Pars caudi-femoralis of Pirif. present.

Both parts of Semit. present.

Both parts of Semit. absent.

Insertion of Semim. extends up to extreme proximal end of Caput tibiae.

Insertion of Semim. typical.

*Sagittarius*

Origin of Obt. int. extends laterally onto ventral surface of ilium.

Tib. ant. without an accessory tendon of insertion.

Tib. ant. without any obvious connection with tibial shaft.

Belly of Per. long. very broad.

Belly of Per. brev. broad distally, the origin extending onto the anterior surface of tibio-tarsus.

Pars interna of Gas. extends around the front of knee.

Tendon of Flex. per. d. II perforated by the deep flexors.

Flex. per. d. III one-headed.

A strong vinculum connects the tendon of the Flex. per. d. III with the F. p. et p. d. III near the lower end of tarso-metatarsus.

Tendon of insertion of Flex. per. d. IV trifurcated.

Belly of F. dig. I. not visible superficially.

Attachment of the F. hal. I. on the femur extends up above the proximal arm of the biceps loop.

Ext. hal. I. slender and single.

Ext. pro. d. III apparently absent.

Ext. brev. d. IV short, confined to about the distal third of tarso-metatarsus.

Abd. d. IV short, confined to about the distal fourth of tarso-metatarsus.

Here again the similarities are hardly more extensive than could be expected in comparing birds in almost any two orders selected at random. It appears not unlikely that *Sagittarius* evolved from an entirely different line of descent than the hawks and falcons, the "hawkish" appearance having been developed by convergent evolution correlated with the predatory habits.

Although *Sagittarius* is peculiar in certain respects I would consider it somewhat more generalized than the hawks and falcons. This is suggested by the presence in *Sagittarius* of the following: Pars ilio-femoralis of the M. piriformis; both parts of the M. semitendinosus; the less extensive origin of the M. tibialis anterior; the broad condition of the M. peroneus longus; the Pars interna of the M. gastrocnemius extending around the front of the knee; the vinculum between the tendons of the two superficial flexors to the third toe; the belly of the M. flexor digitorum longus not visible superficially; the less specialized structure of the M. extensor hallucis longus.

## Typical Falcones

Origin of Obt. int. not connected with ilium.

Tib. ant. with accessory tendon of insertion (except *Pandion*).

Origin of tibial head of Tib. ant. includes a long line down the tibial shaft.

Belly of Per. long. very narrow (absent in *Pandion*).

Belly of Per. brev. typical, not extending onto the anterior surface of tibio-tarsus.

Pars interna of Gas. does not extend around the front of knee.

Tendon of Flex. per. d. II not perforated by the deep flexors.

Flex. per. d. III two-headed (except *Pandion*).

No such vinculum.

Tendon of insertion of Flex. per. d. IV not trifurcated.

Belly of F. dig. I. visible superficially (except *Falco*).

Attachment of the F. hal. I. on the femur does not extend above the proximal arm of the biceps loop.

Ext. hal. I. stout and two-headed.

Ext. pro. d. III well-developed (weak in *Falco*).

Ext. brev. d. IV extends along most of the length of tarso-metatarsus.

Abd. d. IV extends along most of the length of tarso-metatarsus.

COMPARISON OF CATHARTIDAE AND TYPICAL FALCONES  
(Accipitridae, Pandionidae and Falconidae)

*Important similarities.*—Glut. med. et min. present; Ambiens present; Fem. tib. ext. fused with Fem. tib. med; Pars ilio-femoralis of Pirif. absent; origin of Obt. int. does not extend laterally onto ventral surface of ilium; Add. long. consists of a Pars interna and a Pars externa; origin of F. hal. l. typical—not extending above proximal arm of biceps loop; Add. d. II arises from proximal portion of tarso-metatarsus, the tendon very long; no flexor tendons pass through bony canals (except in *Pandion*).

*Important differences*

Cathartidae

Il. troc. med. present as a separate muscle.

Post-acetabular portion of Il. tib. present.

Pars caudi-femoralis of Pirif. absent in *Gymnogyps*, *Sarcoramphus* and *Vultur* (Fisher, 1946, p. 666); present in *Cathartes* and *Coragyps*.

Both parts of Semit. present.

Tib. ant. without accessory tendon of insertion.

Tib. ant. without any obvious connection with tibial shaft.

Belly of Per. long. very broad.

Pars interna of Gas. extends around the front of knee.

Pars media of Gas. consists of two distinct parts.

Plantaris typical.

A strong vinculum connects the tendon of the Flex. per. d. III with the F. p. et p. d. III near lower end of tarso-metatarsus.

Tendon of insertion of Flex. per. d. IV trifurcated.

Belly of F. dig. I. not visible superficially.

Deep flexor tendons Type V.

Belly of F. hal. I. comparatively weak.

Tendon of F. hal. I. is lateral at heel.

Ext. hal. I. slender and single, fleshy all the way to base of hallux.

Typical Falcones

Il. troc. med. fused with the Il. troc. ant.

Post-acetabular portion of Il. tib. absent.

Pars caudi-femoralis of Pirif. present in all forms studied.

Both parts of Semit. absent.

Tib. ant. with accessory tendon of insertion (except *Pandion*).

Tibial head of Tib. ant. arises from a long line down shaft of tibia.

Belly of Per. long. very narrow (absent in *Pandion*).

Pars interna of Gas. does not extend around the front of knee.

Pars media of Gas. undivided.

Plantaris unusually strong (*Falco*) or absent.

No such vinculum.

Tendon of insertion of Flex. per. d. IV not trifurcated.

Belly of F. dig. I. visible superficially (except *Falco*).

Deep flexor tendons Type III (Type V in *Pandion*).

Belly of F. hal. I. large and powerful.

Tendon of F. hal. I. lies directly behind F. dig. I. at heel (except *Pandion*).

Ext. hal. I. stout and two-headed, the belly confined to about the proximal half of tarso-metatarsus.

## Cathartidae

Ext. brev. d. IV arises fleshy from most of the length of tarso-metatarsus.

F. hal. brev. arises from most of the length of tarso-metatarsus.

Tendon of F. hal. brev. perforated by the deep flexor tendon.

The most striking thing brought out by this comparison of the Cathartidae with the typical falconiform birds is the extreme dissimilarity between the muscles of the pelvic limb in the two groups. It hardly seems likely that such wide differences developed from the same line of descent. It is quite possible that the American vultures have no more natural affinity with the hawks and falcons than the owls which were ousted by systematists from the Order Falconiformes many years ago.

## Typical Falcones

Belly of Ext. brev. d. IV confined to the proximal half or less of tarso-metatarsus (except *Pandion*).

Origin of F. hal. brev. confined to proximal portion of tarso-metatarsus.

Tendon of F. hal. brev. not perforated by the deep flexor tendon.

## COMPARISON OF SAGITTARIUS AND PANDION

*Important similarities.*—Il. troc. med. fused with Il. troc. ant.; Glut. med. et. min. present; Ambiens present; Post-acetabular portion of Il. tib. absent; Add. long. divided into a Pars externa and Pars interna; Tib. ant. without an accessory tendon of insertion; Pars media of Gas. single; Gas. forms a single tendon along lower part of shank; Plantaris absent; Flex. per. d. III one-headed; F. p. et p. d. III has no fleshy connection with shaft of fibula; belly of F. hal. l. large and powerful; belly of F. hal. brev. confined to proximal half or less of tarso-metatarsus Add. d. II arises from proximal portion of tarso-metatarsus, the tendon long; tendon of F. hal. brev. not perforated by the deep flexor.

## Important differences

## Sagittarius

Belly of Il. tib. divided proximally.

Fem. tib. ext. present as a separate muscle.

Pars ilio-femoralis of Pirif. present.

Pars caudi-femoralis of Pirif. absent.

Both parts of Semit. present.

Insertion of Semim. unusually high upon Caput tibiae.

Origin of Obt. int. extends laterally onto ventral surface of ilium.

Obt. ext. consists of two bellies with separate areas of insertion.

Pars interna of Add. long. inserts mainly as a thin aponeurotic sheet.

Tib. ant. not connected with shaft of tibia.

Ext. dig. l. passes under a fibrous loop near proximal end of tarso-metatarsus.

Per. long. present.

Per. brev. broad distally, the origin extending onto the anterior surface of tibio-tarsus.

## Pandion

Belly of Il. tib. not divided.

Fem. tib. ext. fused with Fem. tib. med.

Pars ilio-femoralis of Pirif. absent.

Pars caudi-femoralis of Pirif. present.

Both parts of Semit. absent.

Insertion of Semim. typical.

Obt. int. not connected with ilium.

Obt. ext. apparently undivided.

Both parts of Add. long. have fleshy insertions.

Origin of tibial head of Tib. ant. includes a long line down shaft of tibia.

Ext. dig. l. passes under a bony loop near proximal end of tarso-metatarsus.

Per. long. absent.

Per. brev. not connected with anterior surface of tibio-tarsus.

*Sagittarius*

Pars interna of Gas. extends around front of knee.

Tendon of Flex. per. d. II perforated by the deep flexor tendon.

A strong vinculum connects the tendon of the Flex. per. d. III with that of the F. p. et p. d. III near lower end of tarso-metatarsus.

Tendon of Flex. per. d. III perforated by the deep flexor tendons.

Flex. per. d. IV two-headed.

Tendon of insertion of Flex. per d. IV trifurcated.

Tendons of Flex. per. d. II and F. p. et p. d. II do not fuse.

Belly of F. dig. I. not visible superficially.

Deep flexor tendons Type III.

Attachment of F. hal. I. extends up femur above proximal arm of biceps loop.

Tendon of F. hal. I. lies directly behind F. dig. I. at heel.

Ext. hal. I. slender and single, the origin from most of the length of tarso-metatarsus.

Belly of Ext. hal. I. not connected with tendon of Tib. ant.

Apparently no short extensor to the third toe.

Ext. brev. d. IV short, confined to about the distal third of tarso-metatarsus.

Abd. dig. II confined to about the distal one-eighth of tarso-metatarsus.

Lumbricalis very weakly developed.

Abd. d. IV short, confined to about the distal fourth of tarso-metatarsus.

Abd. d. IV inserts on Phal. I.

No flexor tendons pass through bony canals.

*Pandion*

Pars interna of Gas. does not extend around front of knee.

Tendon of Flex. per. d. II not perforated by the deep flexor tendon.

No such vinculum.

Tendon of Flex. per. d. III not perforated by the deep flexor tendons.

Flex. per. d. IV undivided.

Tendon of insertion of Flex. per. d. IV single.

Tendons of Flex. per. d. II and F. p. et p. d. II fuse at heel.

Belly of F. dig. I. visible superficially.

Deep flexor tendons Type V.

Attachment of F. hal. I. does not extend up femur above proximal arm of biceps loop.

Tendon of F. hal. I. is postero-lateral at heel.

Ext. hal. I. stout and two-headed, the origin confined to proximal portion of tarso-metatarsus.

Lateral head of Ext. hal. I. connected with tendon of Tib. ant. by a fleshy slip.

Two well-developed short extensor muscles to the third toe.

Ext. brev. d. IV extends along most of the length of tarso-metatarsus.

Abd. dig. II extends about half-way up tarso-metatarsus.

Lumbricalis strongly developed.

Abd. d. IV extends along most of the length of tarso-metatarsus.

Abd. d. IV inserts on Phal. II.

Tendons of F. dig. I. and F. hal. I. pass through a bony canal.

There is little in this comparison of *Sagittarius* and *Pandion* that suggests any natural relationship. If these birds have been derived from the same ancestral line of descent, the separation of the two groups must have occurred at a very early period and subsequent adaptive radiation has obscured any original similarity of muscle pattern in the hind limb.

## COMPARISON OF CATHARTIDAE AND PANDION

*Important similarities.*—Glut. med. et min. present; Ambiens present; belly of II. tib. not divided; Fem. tib. ext. fused with the Fem. tib. med.; Pars ilio-femoralis of Pirif. absent; Pars caudi-femoralis of Pirif. present (except in *Gymnogyps*, *Sarcorampus* and *Vultur*—Fisher, 1946, p. 666); insertion of Semim. typical—below Caput tibiae; origin of Obt. int. not extensively connected with ilium; Add. long. divided into a Pars externa and Pars interna; Tib. ant. without an accessory tendon of insertion; origin of Per. brev. not extending onto anterior surface of tibio-tarsus; Gas. forms a single tendon along lower portion of shank; Flex. per. d. IV one-headed; deep flexor tendons Type V; origin of F. hal. I. from femur typical, not extending above proximal arm of biceps loop; tendon of F. hal. I. lies postero-lateral at heel; origin of Ext. brev. d. IV from most of length of tarso-metatarsus; Abd. dig. II typical—not unusually long or short; Abd. d. II arises from proximal portion of tarso-metatarsus, the tendon long; Abd. d. IV extends along most of the length of tarso-metatarsus.

*Important differences*

Cathartidae	Pandion
II. troc. med. a separate muscle.	II. troc. med. fused with the II. troc. ant.
Post-acetabular portion of II. tib. well-developed.	Post-acetabular portion of II. tib. absent.
Pars caudi-femoralis of Pirif. absent (except in <i>Cathartes</i> and <i>Coragyps</i> ).	Pars caudi-femoralis of Pirif. present.
Both parts of Semit. present.	Both parts of Semit. absent.
Obt. ext. consists of two bellies with separate areas of insertion.	Obt. ext. apparently undivided.
Pars interna of Add. long. inserts mainly as a thin aponeurotic sheet.	Both parts of Add. long. have fleshy insertions.
Tib. ant. without any obvious connection with shaft of tibia.	Origin of tib. ant. includes a long line down shaft of tibia.
Tendon of Ext. dig. I. passes under a fibrous loop near proximal end of tarso-metatarsus.	Tendon of Ext. dig. I. passes under a bony loop near proximal end of tarso-metatarsus.
Per. long. present.	Per. long. absent.
Pars interna of Gas. extends around front of knee.	Pars interna of Gas. does not extend around front of knee.
Pars media of Gas. with two heads.	Pars media of Gas. undivided.
Plantaris present.	Plantaris absent.
A strong vinculum connects the tendon of the Flex. per. d. III with the F. p. et p. d. III near lower end of tarso-metatarsus.	No such vinculum.
Tendon of insertion of the Flex. per. d. III perforated by the deep flexor tendons.	Tendon of insertion of Flex. per. d. III not perforated by the deep flexor tendons.
Tendon of insertion of the Flex. per. d. IV trifurcated.	Tendon of Flex. per. d. IV not divided.
Tendons of Flex. per. d. II and F. p. et p. d. II not connected.	Tendon of Flex. per. d. II fuses with that of the F. p. et p. d. II at heel.

## Cathartidae

## Pandion

Origin of F. p. et p. d. III includes shaft of fibula.

F. p. et p. d. III not connected with shaft of fibula.

Belly of F. dig. I. not visible superficially.

Belly of F. dig. I. visible superficially.

Belly of F. hal. I. weakly developed.

Belly of F. hal. I. large and powerful.

Ext. hal. I. slender and single, the origin from most of the length of tarso-metatarsus.

Ext. hal. I. strong and two-headed, the origin from the proximal portion of the tarso-metatarsus.

Belly of Ext. hal. I. not connected with tendon of Tib. ant.

Lateral head of Ext. hal. I. connected with tendon of Tib. ant. by a fleshy slip.

Short extensor to third toe very weakly developed.

Two short extensors to third toe very strongly developed.

Belly of F. hal. brev. slender, arising from most of the length of tarso-metatarsus.

Belly of F. hal. brev. very strong, arising from proximal portion of tarso-metatarsus.

Tendon of F. hal. brev. perforated by the deep flexor tendon.

Tendon of F. hal. brev. not perforated by the deep flexor tendon.

Lumbricalis weakly developed.

Lumbricalis strongly developed.

Abd. d. IV weakly developed; inserts on Phal. I.

Abd. d. IV strongly developed; inserts on Phal. II.

No flexor tendons pass through bony canals.

Tendons of F. dig. I. and F. hal. I. pass through a bony canal.

This study of the muscles of the pelvic limb in the Cathartidae and *Pandion* fails to show any close similarity between the two groups. The important points of agreement are far outweighed by the many differences noted.

## COMPARISON OF ACCIPITRIDAE AND FALCO WITH PANDION

*Important similarities.*—Il. troc. med. fused with Il. troc. ant.; Glut. med. et min. present; Ambiens present; Il. tib. with belly undivided and post-acetabular portion absent; Fem. tib. ext. fused with Fem. tib. med.; Pars ilio-femoralis of Pirif absent; Pars caudi-femoralis of Pirif. present; both parts of Semit. absent; insertion of Semim. typical—below Caput tibiae; origin of Obt. int. not connected with ilium; Add. long. divided into a Pars externa and Pars interna; origin of tibial head of Tib. ant. includes a long line down shaft of tibia; origin of Per. brev. not extending onto anterior surface of tibio-tarsus; Pars interna of Gas. does not extend around front of knee; Pars media of Gas. not divided; Plantaris absent (except *Falco*); tendon of Flex. per. d. II not perforated by the deep flexor tendons; no vinculum between the tendons of the Flex. per. d. III and F. p. et p. d. III; tendon of insertion of Flex. per. d. IV not trifurcated; F. p. et p. d. III without any fleshy connection with shaft of fibula (except *Falco*); belly of F. dig. I. visible superficially (except *Falco*); belly of F. hal. I. large and powerful; origin of F. hal. I. from femur does not extend above proximal arm of biceps loop; Ext. hal. I. strong and two-headed, the origin confined to the proximal portion of tarso-metatarsus; Ext. brev. d. IV extends along most of the length of tarso-metatarsus; origin of F. hal. brev. from proximal portion of tarso-metatarsus, the tendon long; tendon of F. hal. brev. not perforated by the deep flexor tendon; Add. d. II arises near the proximal end of the tarso-metatarsus, the tendon long; Abd. d. IV extends along most of the length of tarso-metatarsus.



*Important differences**Accipitridae and Falco*

Pars caudi-femoralis of Pirif. inserts fleshy on femur or by a short, wide tendon.

Obt. ext. with two separate areas of insertion on femur.

Pars interna of Add. long. inserts mainly as a thin aponeurotic sheet.

Tib. ant. with at least one accessory tendon of insertion.

Per. long. present.

Flex. per. d. III two-headed.

Tendon of insertion of Flex. per. d. III perforated by the deep flexor tendons.

Tendons of Flex. per. d. II and F. p. et p. d. II do not unite.

At least one head of a "perforatus" flexor passes medial to tendon of Bic. fem.

Deep flexor tendons Type III.

Tendon of F. hal. I. lies directly behind the F. dig. I. at heel.

Belly of Ext. hal. I. not connected with tendon of Tib. ant.

A single, weak, short extensor muscle to the third toe.

Belly of Ext. brev. d. IV confined to proximal half or less of tarso-metatarsus.

Belly of Add. d. II very weak and confined to about the proximal fourth of tarso-metatarsus.

Lumbricalis very weakly developed.

No flexor tendons pass through bony canals.

The above comparisons of the hawks and falcons with *Pandion* show that these two groups agree in many important respects, although differing to a considerable extent. These differences suggest that *Pandion* is a somewhat aberrant offshoot of the hawk and falcon line of descent. Some of the characteristics of *Pandion* that indicate greater specialization are: absence of *M. peroneus longus*; fusion of the tendons of the two superficial flexors of the index digit; lack of any connection of "perforatus" muscles with the Regio intercondyloidea; fusion of the tendons of the deep flexors of the foot; the fleshy slip connecting the tendon of the *M. tibialis anterior* with the belly of the *M. extensor hallucis longus*.

*Pandion*

Pars caudi-femoralis of Pirif. inserts on femur by a long, narrow tendon.

Insertion of Obt. ext. apparently undivided.

Both parts of Add. long. are fleshy at insertion.

Tib. ant. without an accessory tendon of insertion.

Per. long. absent.

Flex. per. d. III one-headed.

Tendon of Flex. per. d. III not perforated by the deep flexor tendons.

Tendon of F. p. et p. d. II fuses with that of the Flex. per. d. II at heel.

No "perforatus" flexors pass medial to tendon of Bic. fem.

Deep flexor tendons Type V.

Tendon of F. hal. I. is postero-lateral at heel.

Belly of Ext. hal. I. connected with tendon of Tib. ant. by a fleshy slip.

Two well-developed short extensor muscles to the third toe.

Ext. brev. d. IV fleshy almost to base of fourth toe.

Belly of Add. d. II much stronger and extending down to about the middle of the tarso-metatarsus.

Lumbricalis much more strongly developed.

Tendons of F. hal. I. and F. dig. I. pass through a bony canal.

SYNOPSIS OF THE MOST IMPORTANT FEATURES OF THE MUSCLES  
OF THE PELVIC LIMB IN FALCONIFORM BIRDS

	Cathartidae	Sagittarius	Other Falconiform Birds
Myological formula (Hudson, 1937).	ACDXYAmV or CDXYAmV.	BDXYAmV.	ADAm.
Il. troc. med.	A separate muscle ("C" present in formula).	Fused with Il. troc. ant. ("C" absent from formula).	Fused with Il. troc. ant. ("C" absent from formula).
Glut. med. et min. ("D" of formula).	Present.	Present.	Present.
Ambiens ("Am" of formula).	Present.	Present.	Present.
Il. tib.	Post-acetabular position well-developed; belly single.	Post-acetabular position absent; belly double.	Post-acetabular position absent; belly single.
Fem. tib. ext.	Fused with Fem. tib. med.	Present as a separate muscle.	Fused with Fem. tib. med.
Pirif., Pars caudifemoralis ("A" of formula).	Present or absent.	Absent.	Present.
Pirif., Pars iliofemoralis ("B" of formula).	Absent.	Present.	Absent.
Semit. proper ("X" of formula).	Present.	Present.	Absent.
Accessory Semit. ("Y" of formula).	Present.	Present.	Absent.
Semim.	Insertion below Caput tibiae.	Insertion on proximal end of Caput tibiae.	Insertion below Caput tibiae.
Obt. int.	Origin not connected with ilium.	Origin extends laterally onto ventral surface of ilium.	Origin not connected with ilium.
Add. long.	Divided into a Pars externa and Pars interna.	Divided into a Pars externa and Pars interna.	Divided into a Pars externa and Pars interna.
Tib. ant.	No accessory tendon of insertion.	No accessory tendon of insertion.	At least one accessory tendon of insertion (except <i>Pandion</i> ).
Per. long.	Belly broad.	Belly broad.	Belly narrow (absent in <i>Pandion</i> ).
Per. brev.	Typical.	Origin extends onto anterior surface of tibio-tarsus.	Typical.
Gas.	Pars interna extends around front of knee; Pars media double.	Pars interna extends around front of knee; Pars media single.	Pars interna does not extend around front of knee; Pars media single.

	Cathartidae	<i>Sagittarius</i>	Other Falconiform Birds
Plantaris.	Typical.	Absent.	Absent; or strongly developed ( <i>Falco</i> ).
Vinculum connecting tendons of Flex. per. d. III & F. p. et p. d. III ("V" in formula).	Present.	Present.	Absent.
Insertion of Flex. per. d. IV.	Trifurcated.	Trifurcated.	Not trifurcated.
F. dig. I.	Belly not visible superficially.	Belly not visible superficially.	Belly visible superficially (except <i>Falco</i> ).
Deep flexor tendons.	Type V.	Type III.	Type III (V in <i>Pandion</i> ).
F. hal. I.	Origin from femur typical.	Origin from femur unusually high—extending above proximal arm of biceps loop.	Origin from femur typical.
F. hal. I.	Tendon is posterolateral at heel.	Tendon lies directly behind the F. dig. I. at heel.	Tendon lies directly behind the F. dig. I. at heel (except <i>Pandion</i> ).
Ext. hal. I.	Slender and single.	Slender and single.	Strong and two-headed.
Ext. brev. d. IV.	Extends along most of the length of tarso-metatarsus.	Confined to about the distal third of tarso-metatarsus.	Extends along most of the length of tarso-metatarsus.
F. hal. brev.	Tendon of insertion perforated by the deep flexor.	Tendon of insertion not perforated.	Tendon of insertion not perforated.
Abd. d. IV.	Extends along most of the length of tarso-metatarsus.	Confined to about the distal fourth of tarso-metatarsus.	Extends along most of the length of tarso-metatarsus.
Hypotarsus.	No tendons pass through bony canals.	No tendons pass through bony canals.	No tendons pass through bony canals (except <i>Pandion</i> ).

## DISCUSSION AND CONCLUSIONS

A comparative study was made of the entire musculature of the pelvic limb in two genera of American vultures (*Cathartes* and *Coragyps*), a secretary bird (*Sagittarius*), representatives of several genera of the Accipitridae (*Accipiter*, *Buteo*, *Aquila*, *Circus*) an osprey (*Pandion*) and three species of falcons (*Falco*).

The three major groups of "diurnal birds of prey" were found to differ in many important respects, supplementing the already well known differences in external structure, osteology, deep flexor tendons and "formula muscles" of Garrod (1874).

As shown by Compton (1938) *Pandion* agrees in certain respects with the Cathartidae. However, a study of the complete musculature of the pelvic limb strongly indicates that *Pandion* cannot be considered as belonging with the American vultures. The osprey apparently represents a highly aberrant offshoot of the hawk and falcon tribe but differs in so many ways that it seems best to place it in a separate suborder.

Although Howell (1938) suggested many changes in names of thigh muscles after studying these in the domestic fowl, and has been followed by Fisher (1946), the present paper uses the terminology employed by Hudson (1937) which is based on Gadow (1891). It is believed that a great amount of additional work should be done on innervations and homologies of the muscles in many different orders of birds before changes in muscle nomenclature are justified. Until such work is accomplished, stability of names should be considered more important than hastily contrived changes.

It has long been recognized that the Cathartidae, "Falcones" and *Sagittarius* differ in many important respects and this is clearly reflected in the various schemes of classification proposed for the "diurnal birds of prey." The following selected examples show some of the trends:

- Sharpe (1891)—Order CATHARTIFORMES, Suborder PSEUDOGRYPIII  
 Order ACCIPITRIFORMES, Suborder SERPENTARI  
 Suborder ACCIPITRES  
 Suborder PANDIONES  
 Suborder STRIGES
- Gadow (1893)—Order FALCONIFORMES  
 Suborder CATHARTAE, Family Cathartidae  
 Suborder ACCIPITRES, Family Gypogeranidae  
 Family Vulturidae  
 Family Falconidae  
 Family Pandionidae
- Peters (1931)—Order FALCONIFORMES  
 Suborder CATHARTAE, Family Cathartidae  
 Suborder FALCONES  
 Superfamily Sagittarioidea  
 Family Sagittariidae  
 Superfamily Falconoidea  
 Family Accipitridae (including Pandioninae)  
 Family Falconidae

In view of the profound differences now known to exist between these groups the following arrangement is proposed:

- Order CATHARTIDIFORMES, Family Cathartidae
- Order SAGITTARIIFORMES, Family Sagittariidae
- Order FALCONIFORMES
  - Suborder FALCONES
    - Family Accipitridae
    - Family Falconidae
  - Suborder PANDIONES
    - Family Pandionidae

It appears quite possible that the American vultures, secretary bird and the hawk and falcon tribe represent three entirely different lines of avian evolution and are no more closely related to each other than to the owls, which have long been separated from the Order Falconiformes. If these three lines were derived from a common source subsequent adaptive radiation has greatly obscured the original similarity of muscle pattern in the pelvic limb. I strongly suspect that the "hawkish" appearance of *Sagittarius* has been developed through convergent evolution.

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## Some Notes on Indiana Mammals<sup>1</sup>

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From the time when first efforts were made to form a study collection for the purpose of acquainting forestry students with representative mammalian groups occurring within the state, occasional rare specimens of Indiana mammals or interesting records of common species came into our hands as a result of outside contacts. Some valuable records began to accumulate in this casual manner. Conaway has also done some collecting in southeastern Indiana with a number of records from Dearborn County. A certain amount of collecting has been done by the authors together,<sup>2</sup> usually of local and intensive nature directed at the possible discovery of species heretofore regarded as uncommon or rare. Accordingly considerably time has been spent trapping for shrews, jumping mice, and lemming mice, to name a few examples, and a number of excursions have been made for bats.

No effort has been made to secure a complete representation of species from any one county and no state distribution pattern has been worked out for any one species. This accounts for the fact that some common species have been omitted entirely from the list while others, e.g., opossum, red fox, and cottontail are noted. Their inclusion is incidental to our efforts to record species of greater rarity, and primarily for the sake of recording the specimen accompanied by pertinent data.

Most of the common small mammals including those just mentioned are accorded almost universal distribution in Indiana based upon sight records or upon published reports usually not accompanied by museum specimens or without the locality being known (Lyon, 1936). With a few exceptions the species listed below include new county records which are designated by our accession numbers. The skin and skull (infrequently only one) are deposited in the wildlife collection of the Department of Forestry and Conservation, Purdue University. Unless otherwise noted, when conflicting nomenclature occurs between Lyon, and Bole and Moulthrop (1942), the latter are followed since their taxonomic treatment is the most recent for mammals in this area.

Reiterating the introductory remarks of Lyon, it is hoped that a more active interest in Indiana mammals will be stimulated in students and in others. Much remains to be done in Indiana mammalogy. For the purpose of future taxonomic determinations and studies of geographical variation as well as for the historical record, good collections of all species are appropriate. A case in point is the uncertain taxonomic status of the chipmunk genus *Tamias*. There are perhaps three subspecies of this rodent within the state (Bole and Moul-

<sup>1</sup> Journal Paper No. 305, Purdue University Agricultural Experiment Station.

<sup>2</sup> Other students, including M. L. Kuns, R. G. Prasil, and E. E. Provost, have also contributed specimens and information.

throp), but in spite of the familiar sight of it, museum skins are available from only thirteen Indiana counties. Other interesting questions as yet unanswered pertain to the present state distribution of most species, the status of the red fox recently so conspicuous by its numbers and of the less common coyote. Recent records of the badger are rare and the otter probably has vanished from the state within the last 15 years. Completely unknown is the status of the star-nosed mole, of shrews of the genus *Sorex*, of some bats, jumping mice, and the swamp rabbit.

*Didelphis virginiana virginiana*. Virginia Opossum.—A juvenile female (No. 378) was taken in Tippecanoe County by R. G. Prasil, October 18, 1946. Measurements from other individuals are available including a male from Newton County.

*Scalopus aquaticus machrinus*. Prairie Mole.—Specimens of both sexes from Tippecanoe County are in the collection. A male (No. 380) was taken on the campus in March, 1942, and a female (No. 377) taken May 26, 1947, is from the New York Central Railroad fill near Lafayette. A female (No. 390) taken May 7, 1946, near Battle Ground, had three well-developed embryos.

*Cryptotis parva harlani*. Gray Cryptotis.—Five formalin specimens with no dates are from Versailles State Park, Ripley County, collected there by John C. Kase. These were found dead along roadsides in wooded areas, apparently having been killed and left lying by foxes.

Three specimens (Nos. 383, 384, 385) were trapped by Merle L. Kuns in permanent, heavily grazed pasture in Monroe Township, Carroll County, September 8, 1946. Skulls only of these are preserved.

Our analysis in the fall of 1946 of 145 barn owl pellets from Tippecanoe County revealed 47 skulls of this species taken by owls (Kirkpatrick and Conway, 1947). This indicated that the shrew was more abundant locally than we had previously suspected. On October 4, 1946, a male was caught by hand where it had taken refuge beneath a burlap bag lying in a fallow, hill-top field three miles southwest of Lafayette. Approximately 25 trap nights shortly thereafter in this field, using peanut butter, produced no *Cryptotis*. On October 22 and 23, a total of 92 trap nights during which a bait combination of pulverized black walnut meats, bacon fat, and peanut butter was employed, produced 22 *Cryptotis*, and in addition, 28 *Microtus o. ochrogaster*, 5 *Peromyscus leucopus noveboracensis*, and a single *Blarina*. On November 6, only 1 *Cryptotis* was taken from 46 traps using the same bait along with 1 *Blarina* and 9 *ochrogaster*. During the months of November and December, 1946, sporadic trapping in the Forestry Department tree nursery (within West Lafayette) caught 7 *Cryptotis* at least 3 of which were in the light or so-called summer pelage.

Skulls of this species have also been found in barn owl pellets from Dearborn County.



Of 15 *Cryptotis* in our collection, 9 are males and 6 are females.

*Blarina brevicauda kirtlandi*. Lake States Blarina.—Two records for Jasper County are a female (No. 382) taken June 30, 1946, and a male (No. 235) on September 4, 1946. These were from the Jasper-Pulaski State Game Farm. From more than 400 trap nights in varied habitats in this area, 25 individuals of this species represented the most frequently caught mammal.

*Myotis lucifugus lucifugus*. Little Brown Bat.—A record from Ripley County is a female (No. 381) collected from a cave October 12, 1946. On the evening of December 28, 1946, we took 94 *Myotis* from Wyandotte Cave in Crawford County. Upon close examination two of these proved to be *lucifugus* males, the remaining 92 being the Indiana type species, *sodalis*. On December 29 a single *lucifugus* was found in Donnellson Cave, Lawrence County in company with perhaps 200 *Eptesicus f. fuscus*. On April 8, 1947, Conaway and Kuns recorded *lucifugus* (Nos. 367, 370) from Slaughterback's Cave, Harrison County.

*Myotis sodalis*. Indiana Bat.—Of 92 individuals of this species from Wyandotte Cave, Crawford County (the type locality) taken December 28, 1946, the sex ratio was 71 males to 21 females. On this and a later date 17 other caves in southern Indiana were entered by Conaway with no *sodalis* found. A single female (No. 366) was shot in Tippecanoe County, May 13, 1947, near the edge of a woods in association with red bats (*Lasiurus b. borealis*) and silver-haired bats (*Lasionycteris noctovagans*).

*Pipistrellus subflavus obscurus*. Northern Pipistrelle.—This species is represented in the collection by county records from Dearborn, Ripley, and Harrison Counties. All pipistrelles collected in winter and early spring were from humid caves. On December 29, 1946, perhaps 50 were observed in Langton's Cave, Harrison County but no other species were seen. They were always hanging singly and covered with fine droplets of moisture giving them a silvery appearance. Fifteen individuals taken from this cave included 11 males and 4 females.

Five individuals taken from Sullivan's Cave, Lawrence County, on December 30, were males. On the same day, 8 males and 1 female were taken from Eller's Cave, Monroe County.

In April, 1947, Conaway observed pipistrelles in several caves in Orange County.

*Eptesicus fuscus fuscus*. Big Brown Bat.—On December 17, 1946, five specimens were collected in Tippecanoe County. They had taken shelter in a long, concrete culvert which drains the incline of U. S. Highway 52 as it crosses the Wabash River. Four of these bats were in a compact cluster. The temperature within the tunnel was above freezing indicated by a trickle of water on the floor, whereas the outside temperature was about 25°. No bats were seen on subsequent visits to the culvert.

A male (No. 293) is from Harrison County on December 27, 1946. It was taken from Rat Cave, a shallow cave in the limestone bluff overlooking the Ohio River near Tobacco Landing. When the cave was visited about 8:00

p. m., perhaps 15 *Eptesicus* were flying about the cave. Apparently they had come from deep fissures and recesses. Some issued from a small hole in the ceiling. One pair observed together in a crevice were presumably copulating. During the day no bats had been seen in the cave. The temperature for that evening was estimated at about 50 degrees. For the period of December 27 and 28, the maximum and minimum daily temperatures at Tell City (nearest station with available record) were 65 and 47 degrees respectively.

On December 29, 1946, about 200 *Eptesicus* were observed hibernating in Donnellson Cave, Spring Mill State Park, Lawrence County. Twenty-four of these collected at random gave a sex ratio of 17 males to 7 females.

*Lasionycteris noctivagans*. Silver-haired Bat.—At dusk on May 13, 1947, two specimens were shot at the edge of the Purdue Dairy Woods. Both were females. Most authors describe this species as having a dark or blackish-brown coat and such is our No. 365. Specimen No. 364, however, is markedly lighter, being a cocoa-brown throughout so that when viewed together these individuals clearly show the occurrence of two color phases.

*Nycticeius humeralis*. Evening Bat.—Both skins in our collection represent the first two recorded occurrences of this species in Indiana. A male specimen (No. 391) was taken May 2, 1942, in Dearborn County by Conaway (Kirkpatrick, 1943). A female (No. 374) was taken in Tippecanoe County on May 23, 1947, which contained 2 very small embryos.

*Lasiurus borealis borealis*. Northern Red Bat.—Two females (Nos. 388, 389) were taken May 6, 1942, in Dearborn County. A number of red bats have been taken in Tippecanoe County including two pregnant females (Nos. 375, 376). Each had 3 fetuses. One taken May 23, 1947, had 9 mm. fetuses and another taken May 31 had uterine young of 16 mm.

*Martes pennanti pennanti*. Eastern Fisher.—In April, 1946, Conaway found a skull fragment, including two molar teeth, at the site of an old Indian village near Laughery Creek in Ohio County. We are indebted to Dr. W. H. Burt, University of Michigan, for confirming this as part of a fisher skull. Apparently this is the only preserved material of this species from Indiana. The possibility exists, of course, that the animal originated in some other region and was carried to this area by the Indians.

*Mustela rixosa allegheniensis*. Allegheny Least Weasel.—A male (No. 178) was taken near Orland in Steuben County, January, 1944.

In August, 1946, a male (No. 392) was captured alive in a West Lafayette fraternity house, and presented to us by Mr. Donald E. Stullken of the Purdue Biology Department. This small carnivore was kept alive in the laboratory for more than 10 months but never forsook its viciousness. Live mice and half-grown albino rats offered to the weasel were dispatched by biting behind the right ear. In killing the rats, which weighed more than the weasel, a violent struggle usually took place with the weasel astride the victim's back, gripping with all feet as they rolled and tossed about. The rats were fre-

quently tugged about by the nose before a satisfactory head hold was obtained. Food was usually carried into a small box and eaten or stored there.

The weasel showed fear of a bat and of a small snake which were placed in its cage. It would not eat butterflies or shrews (*Blarina*) either skinned or entire.

On November 8, 1946, a least weasel was seen as it took refuge in a mole tunnel near Battle Ground.

All of these weasels and one taken on the Jasper-Pulaski State Game Farm, January 23, 1943, were in the brown coat.

*Mustela frenata noveboracensis*. New York Weasel.—A female was caught alive by Conaway during a flood period in the Ohio River bottom land in Dearborn County. Two males (Nos. 280, 395) were taken October 29, 1946, from a 40 acre deciduous woods near West Lafayette, Tippecanoe County, after a long period of continuous trapping for this species. None were taken after this date.

*Mustela vison mink*. Common Mink.—An adult male (No. 332) was trapped at a small hollow in the base of a tree near the Purdue Golf Course, Tippecanoe County, on January 27, 1947.

On June 11, 1947, an adult female and two of her three third-grown kits were captured at the Jasper-Pulaski State Game Farm. These represent records from Jasper County and the adult and one of the young are numbered 396 and 397 respectively in the Purdue collection.

*Vulpes fulva fulva*. Common Red Fox.—On May 3, 1947, a lactating female and her four 4-to-5-week old pups were killed by a farmer in Lauramie Township, Tippecanoe County. There were 2 pups of each sex. One of the juveniles (No. 357) is in the collection.

During the last few years a number of Indiana counties have placed bounties upon foxes in an attempt to reduce their numbers. It is not uncommon for some north-central counties to pay bounty on as many as one hundred foxes for a one month period, especially during late winter and early spring.

The winter food habits of Indiana red foxes have been studied recently by Kase (1946).

*Canis latrans*. Coyote.—We have the skull of a specimen (No. 149) taken near Jefferson, Clinton County, on January 15, 1942, by Mr. Paul Heavilon. No skin, sex, or measurements were available.

*Citellus tridecimlineatus tridecimlineatus*. Eastern Striped Ground Squirrel.—The earliest sight record for Tippecanoe County in the spring, 1947, was April 3. Four specimens were collected April 25. Three of these were males with enlarged, scrotal testes. The female had enlarged ovaries with young follicles. On May 31, a pair of females were snared, both of which were lactating.

*Citellus franklinii*. Franklin's Ground Squirrel.—A male (No. 398) was

taken April 26, 1942, near Brookston in White County. A male and a female (Nos. 222, 237) were taken at the Jasper-Pulaski State Game Farm the first week in September, 1946.

Several specimens have been taken from the Monon Railroad embankment between Battle Ground and Ash Grove, Tippecanoe County, where a colony seems to exist. This species is neither so abundant nor widespread as *C. t. tridecimlineatus* and in this vicinity appears to have a preference for the habitat provided by railroad fills.

D. E. Stullken snared 7 *franklinii* from May 9-11 with females in estrus. Copulation was observed among the captives on May 17 and 23.

*Tamias striatus ohionensis*. Ohio Brown Chipmunk.—Chipmunks in the Purdue collection from Dearborn, Parke, Tippecanoe, and Jasper Counties are all considered here as belonging to this subspecies since these counties fall within the range of *ohionensis* as described by Bole and Moulthrop. Considerable variation is apparent between the specimens from Dearborn County in southeastern Indiana and the specimens from Tippecanoe County in northwestern Indiana. Until a much larger series of specimens from throughout the state is available, the exact subspecific distribution of the Indiana chipmunks cannot be determined.

*Sciurus hudsonicus loquax*. Middle Eastern Red Squirrel.—Both sexes of this species from Tippecanoe County are in our collection including an immature female (No. 402) taken October 15, 1946. In this vicinity populations of the red squirrel are apparently restricted to certain more or less limited wooded areas with good undergrowth and no grazing. The heaviest population occurs in a woods near West Lafayette in which the two other local species of *Sciurus* are also abundant as well as *Tamias* and the flying squirrel (*Glaucomys*).

A juvenile female (No. 405) is from Jasper County, taken on May 17, 1946, when a litter of 5 with open eyes was found in a wood duck nest box in the Jasper-Pulaski State Game Farm. The measurements of this specimen are: Wt. 26.8 gm.; total length 167 mm.; tail length 64 mm.; hind foot length 34 mm.

*Sciurus carolinensis carolinensis*. Southern Gray Squirrel.—A male (No. 208) and a female (No. 187) are from Tippecanoe County. The latter was taken August 6, 1946, and contained 2 fetuses averaging 65 mm. in length. The female is of further interest because of its reddish-fawn coat. The usual grizzled gray color appears in only a few irregular spots about the head and fore legs.

*Sciurus niger rufiventer*. Middle Western Fox Squirrel.—A female (No. 216) is from Tippecanoe County on August 23, 1946. A considerable number of this species has been collected in Tippecanoe, Montgomery, Jasper, and Pulaski Counties for a reproduction study. Measurements and breeding data are available for these but no specimens have been preserved.

*Glaucomys volans volans*. Flying Squirrel.—Specimens of both sexes from Tippecanoe County are in the collection. On September 4, 1946, an adult female (No. 239) was taken in Pulaski County. On March 29, 1946, a litter of 3 naked, blind young were found in Jasper County. The nest was in the rotten stub of a small tree about 7 feet from the ground.

*Geomys illinoensis*. Illinois Pocket Gopher.—This species has been the subject of an undergraduate thesis by Conaway, who has placed 36 specimens in the Purdue collection from Tippecanoe County, and his observations will be the basis for an appropriate note in the near future. Sight records of gopher activity were also made in Warren and Benton Counties.

*Peromyscus leucopus noveboracensis*. Common Deer Mouse.—A male and a female (Nos. 229, 230) were taken in Jasper County, September 3, 1946. A male (No. 360) was taken at Tobacco Landing, Harrison County, April 7, 1947.

*Peromyscus maniculatus bairdii*. Prairie White-footed Mouse.—Records for Dearborn and Tippecanoe Counties are represented by a small series including both sexes. On November 10, 1946, ten individuals including 2 lactating females, were taken in 18 traps set in an open weed field in Tippecanoe County.

*Neotoma magister*. Allegheny Wood Rat.—By following the directions given by Hickie and Harrison (1930), we arrived at perhaps the same spot where they first captured wood rats in Indiana which is Tobacco Landing in Harrison County. On the warm night of December 27, 1946, a total of 8 of these unsuspicious creatures came into our traps, of which 6 were taken alive. They exhibited no fear of new, wooden live traps, but entered them readily for ear corn bait. All of the *Neotoma* taken were adults of which 3 were males and 5 were females.

Four of the live-trapped rats were maintained in the laboratory without difficulty for approximately 3 months. As food they accepted a variety of vegetables, grains, and nuts. One individual ate peanut butter avidly while the others showed little interest in it. From the first our live specimens were docile and curious. They permitted stroking and took food from our fingers within a few hours after their capture, but would never permit themselves to be picked up. When agitated they would stamp the hind feet to make a thumping sound.

As long as we held them captive, no wood rat would ever tolerate another of either sex in the same cage. When placed together, their peaceful and drowsy attitude instantly changed to one of combat. Standing on their hind legs and propped up by the tail, they sparred and jousting with the forefeet, constantly grinding their teeth with a soft rasping noise and vibrating the vibrissae at a tremendous rate. Apparently it was the purpose of each individual to catch the other off balance and then use the advantage to inflict an injury, although we could never detect a wound as a result of these encounters. To our knowledge no sounds were ever uttered by our captive wood rats.

In addition to the local occurrence of *Neotoma* at Tobacco Landing, we have proof of their presence on the Harrison State Forest where the limestone escarpment borders the Ohio River. On two occasions unmistakable signs of their activity were found there and such identifiable parts as feet, toes, and vibrissae were left in our steel traps. No signs of these rats were noted along similar cliffs along the Ohio in Crawford County, but definite evidence of their occurrence was found in Orange County. In a small cave on a hill just west of Valeene many piles of debris consisting of wood, bones, rocks, and scattered nuts were found, as well as holes in the cave floor and walls.

*Synaptomys cooperi saturatus*. Illinois Lemming Mouse.—A female (No. 417) taken January 28, 1943, is a record from Ripley County. Four specimens comprising both sexes were taken in an orchard December 21, 1946, in Tippecanoe County. Of these 3 were immature and the other an adult male. An apparent decline in microtine mice occurred beginning about January, 1947, and after this *Synaptomys* virtually disappeared. On February 18, when the orchard site was retrapped, mostly unused runways and old middens were found and signs of recent activity were scarce. A single female was taken on this date. Other areas which sustained what appeared to be (on the basis of signs) high winter populations, when visited in the spring showed no indication of recent use.

It was noted in a previous paper that the lemming mouse is a minor item of winter prey for 3 species of owls in this vicinity (Kirkpatrick and Conaway). It is not certain whether this is due to the relatively greater abundance of other mice or to the more secretive habits of *Synaptomys*. Skulls of this species were found in barn owl pellets before we were successful in capturing them in traps.

A male (No. 418) was taken in an old cranberry bog, Warren County, November 19, 1946.

*Microtus pennsylvanicus pennsylvanicus*. Eastern Meadow Vole.—A female (No. 419) is from Dearborn County, taken March 26, 1946. A series from Tippecanoe County includes both sexes. On May 2, 1947, a female (No. 359) was taken which was found to have 5 pea-sized embryos. On September 6, 1946, a single individual of this species was taken in Pulaski County during more than 400 trap nights in that area. An immature female (No. 371) was taken in the cranberry bog area in Warren County, May 15, 1947.

*Microtus ochrogaster ochrogaster*. Middle Western Prairie Vole.—A series of 10 including both sexes are from Dearborn County. Tippecanoe County is represented by 2 male specimens. This species was very abundant in the fall and winter of 1946 and catches during this period were always heavy with *ochrogaster*. On October 24, 1946, in 92 trap nights 28 *ochrogaster* were taken of which 5 were pregnant females, in addition to a number of shrews and deer mice (see *Cryptotis*). The abundance of this mouse is also evident from the winter foods of 4 local species of owls (Kirkpatrick and Conaway). In a total of 1098 prey items, as determined by pellet analysis, there was a

marked preponderance of *ochrogaster* including 557 individuals or 50.7 per cent of all the food items. This species was the most important food item of each of the 4 owl species (barn owl, long-eared owl, short-eared owl, great horned owl).

On October 19, 1946, a female (No. 420) was taken from the cranberry bog area in Warren County.

*Pitmys pinetorum scalopsoides*. Northeastern Pine Vole.—Two males (Nos. 428, 429) and a female (No. 427) are recorded from Tippecanoe County. All were taken in deciduous woods in the fall of 1946. Apparently this vole is relatively rare, since these three individuals are all that have been taken in this vicinity.

*Pitymys pinetorum auricularis*. Bluegrass Pine Vole.—A series of 7 specimens including both sexes are available from Dearborn County. All of these were captured in a large orchard near Aurora.

*Ondatra zibethica zibethica*. Common Muskrat.—A female (No. 260) was taken September 7, 1946, in Pulaski County.

*Rattus norvegicus*. Norway Rat.—A female (No. 275) represents our only skin, taken in Tippecanoe County, September 17, 1946. In the fall and winter of 1946, field-living populations of this rodent were noted along fence rows and ditches in various parts of the county. These colonies were a source of prey for great horned owls (Kirkpatrick and Conaway).

*Zapus hudsonius brevipes*. Short-footed Jumping Mouse.—A single immature female (No. 246) was taken in Pulaski County, September 6, 1946. It was the only one of its kind taken from 82 traps placed in grass and weed cover at the edge of a pine wind break. The following night 119 traps were set in the same location but no *Zapus* was captured.

*Sylvilagus floridanus mearnsii*. Middle Western Cottontail.—Our only specimen with pertinent data is a juvenile female (No. 189) from Tippecanoe County, August 9, 1946. Sex and weight data are available for a number of other cottontails from this county.

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## Vertebrate Animals Feeding on the Mormon Cricket

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In 1848 the Utah pioneers learned the value of the California gull as a friend of the farmer and a destroyer of the Mormon cricket, *Anabrus simplex* Haldeman. Various workers have added to our knowledge of vertebrate animals, found to feed on this large and destructive range insect. La Rivers<sup>1</sup> in 1941 presented numerous observations of birds feeding on Mormon crickets in Nevada.

During the three season, 1943 to 1945, inclusive, a moderately heavy infestation of Mormon crickets came down from the hills to invade outlying small grain and alfalfa fields located approximately three miles southeast of Kanosh, in Millard County, Utah. Soon after the "advanced guard" of the outbreak reached these fields, the migration each time reversed its line of march and returned to the hills. Crops in only a few fields suffered damage of consequence, the chief injury being inflicted on range land forage. On May 11, 1943, the crickets were crossing the oiled highway into new fields; however, on May 15, only small numbers of the crickets still were present in these fields. On May 14, 1944, nymphal Mormon crickets and grasshoppers were very abundant in the same foothill-area fields. Five thousand turkeys were used to feed on and reduce cricket and grasshopper abundance in several of the alfalfa and small grain fields, the turkeys being introduced on May 30, 1945. This was shortly before the Mormon crickets turned about and again moved out of cultivated fields, becoming difficult to locate as scattered bands in the juniper and sagebrush land to the south and east.

A number of birds and lizards were collected in this general area, their stomachs being preserved and later examined under a binocular microscope in the college laboratory.

*Birds.*—An Arkansas kingbird, *Tyrannus verticalis*, taken May 15, 1943, about two and one-half miles southeast of Kanosh, Utah, still contained two Mormon cricket nymphs, three grasshoppers, one clickbeetle, three flies, one pentatomid bug plus beetle fragments, which still were present in recognizable condition.

Two American ravens, *Corvus corax*, collected May 15, 1943, and May 14, 1944, contained seven and thirteen *A. simplex* nymphs, respectively. Also seven grasshoppers, one field cricket, two cutworms, one darkling beetle and four *Silpha lapponica* Hbst. beetles were present in the stomachs.

A western mockingbird, *Mimus polyglottos leucopterus*, taken May 14, 1944, contained parts of three Mormon cricket nymphs, five grasshopper

<sup>1</sup> LA RIVERS, IRA 1941—The Mormon cricket as food for birds. The Condor, 43:65-69.

nymphs, one weevil and parts of four other beetles, 2 lepidopterous larvae that appeared to be cutworms, and two western harvester ants.

A western robin, *Turdus migratorius propinquus*, was taken on May 15, 1943, which held the abdomen of a male *A. simplex*, three grasshopper nymphs, two cutworms, one pentatomid bug, parts of a beetle, and two earthworms.

Five western meadowlarks, *Sturnella neglecta neglecta*, were taken, one on May 15 and two on June 10, 1943, one on May 14, 1944, and one on May 30, 1945. These stomachs all contained Mormon cricket nymphs, totaling 15, besides 24 nymphal and one adult Elliott's grasshopper, nine lepidopterous larvae, mostly cutworms (three being army cutworms), eight beetles of which two were elaterids; one alfalfa weevil and two other weevils.

A green-tailed towhee, *Oberholseria chlorura*, taken on May 15, 1943, among sage and junipers had eaten one nymphal female *A. simplex*, one grasshopper nymph, two lepidopterous larvae and two beetles, one of which was a buprestid.

A western vesper sparrow, *Poocetes gramineus confinis*, taken May 15, 1943, contained parts of two nymphal Mormon crickets, two small grasshopper nymphs, three Hemiptera and three beetles, one a Scolytidae.

A white-crowned sparrow, *Zonotrichia leucophrys*, was collected the same day, containing parts of three nymphal *A. simplex*, four small grasshopper nymphs, one mirid nymph, four larvae and one pupal Lepidoptera and two ants.

A western lark sparrow, *Chondestes grammacus strigatus*, also taken May 15, 1943, held one nymphal Mormon cricket, two grasshopper nymphs, one *Lygus elisus* Van D. bug besides two other bugs, three beetles, one an elaterid, the other a weevil, and two lepidopterous larvae.

No recognizable parts of Mormon crickets were found in several stomachs of small birds, also taken among junipers and sage on the above dates.

*Lizards*.—Three sagebrush swifts, *Sceloporus graciosus graciosus*, two taken May 15, 1943, the other May 30, 1945, all had recently eaten *A. simplex*, parts of six nymphs of this species being recognized. In addition, 13 grasshopper nymphs, mostly Elliott's, a specimen each of the two bugs, *Lygus elisus* and *Chlorochroa sayi* Stal, three beetles—a click beetle, a scarabaeid and a fleabeetle, one blowfly, five termites and one Collembola.

Five desert whiptail lizards, *Cnemidophorus tesselatus tesselatus*, apparently common in the brushy areas, were collected. Three of these were taken May 15, 1943; the others May 30, 1945. Recognizable insects included 11 Mormon cricket nymphs in the stomachs and one such cricket, just captured, in the mouth of a lizard, four grasshopper nymphs in two stomachs, one pentatomid bug, seven beetles, including an adult clickbeetle and a wireworm, two larvae and an adult moth, one each of larva, pupa and adult Diptera.

Three leopard lizards, *Gambelia wislizenii*, were taken May 5 and June 10, 1943. These held 10 Mormon cricket nymphs, five nymphal and two adult (*Trimerotropus* and *Aulocara elliotti* Th.) grasshoppers, five beetles included a large tenebrionid and a scarabaeid beetle, one lepidopterous caterpillar and two ants.

## Two New Crayfishes of the Genus *Orconectes* from Arkansas, with a Key to the Species of the Hylas Group (Decapoda, Astacidae)

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Ortmann (1931) defined three sections of the Subgenus *Faxonius* (= Genus *Orconectes*): *Limosus* Section (p. 64), *Propinquus* Section (p. 65), and *Virilis* Section (p. 91). The new species herein described belong to the *Propinquus* Section.

The *Propinquus* Section is defined as follows: Gonopods of male extending cephalad to or beyond the coxopodite of third pereopod; tips, separated for a relatively great distance, straight or only slightly curved except in *O. peruncus* and *O. punctimanus*, and in neither of these is the curve as great as in the members of the *Virilis* Section (Compare figs. 21, 22, and 23 with the pleopod of *O. virilis*, fig. 16).

Ortmann (1931) recognized only two Groups of the *Propinquus* Section, the *Propinquus* Group and the *Rusticus* Group. Creaser (1931, 1933) described several new species belonging to this Section, and (1934: 2, 3, 7) proposed a third group which he called the Hylas Group, the members of which are in some respects intermediate between the members of the *Propinquus* and *Rusticus* groups. The crayfishes described in this paper belong to the Hylas Group.

### Group of *ORCONECTES PROPINQUUS*

*Diagnosis*.—Terminal elements of first pleopod of first form male relatively short—reaching cephalad to coxopodite of third, or between those of second and third, and rarely in *erichsonianus* to that of second pereopod. Central projection never setiform; both central projection and mesial process subequal in length. Annulus ventralis flat or with a transverse elevation cleft along median line; caudal portion of annulus with no conspicuous caudally projecting prominence.

*Species*: *Orconectes propinquus propinquus* (Girard), *O. p. sanborni* (Faxon), *O. p. jeffersoni* Rhoades, *O. erichsonianus* (Faxon), and *O. obscurus* (Hagen).

### Group of *ORCONECTES HYLAS*

*Diagnosis*.—Terminal elements of first pleopod of first form male long—reaching to coxopodite of second or first pereopod. Central projection and mesial process subequal in length, or central projection longer. Central projection may or may not be setiform. Annulus ventralis usually appearing abnormally large, and except in *O. marchandi*, with cephalic region almost flush with the sternum anterior to it or concave; caudal portion of annulus prolonged into a free caudally projecting prominence (only slightly developed

in *O. punctimanus*). This is the best single diagnostic character of the group.

*Species:* *Orconectes hylas* (Faxon), *O. peruncus* (Creaser), *O. quadruncus* (Creaser), *O. punctimanus*\* (Creaser), *O. leptogonopodus*, and *O. marchandi* sp. nov.

#### Group of ORCONECTES RUSTICUS

*Diagnosis.*—Terminal elements of first pleopod of first form male long—reaching cephalad to coxopodite of second or first pereiopod. Central projection always longer than mesial process; central projection always setiform. Annulus ventralis with elevated cephalic area which is cleft along midventral line; caudal portion of annulus not prolonged into a caudally projecting prominence.

*Species:* *Orconectes rusticus rusticus* (Girard), *O. r. placidus* (Hagen), *O. r. forceps* (Faxon), *O. r. mirus* (Ortmann), *O. r. barrenensis* Rhoades, *O. juvenilis* (Hagen), *O. medius* (Faxon), *O. luteus* (Creaser), *O. neglectus* (Faxon), *O. menae* (Creaser).

#### *Orconectes marchandi* sp. nov.\*\*

*Diagnosis.*—Rostrum with lateral spines, margins somewhat thickened and slightly converging. Areola approximately five times longer than broad with two or three punctations in narrowest part—length about 32% of entire length of carapace; postorbital ridges terminating cephalad in heavy corneous spines; small lateral spine on either side of carapace; in male, hooks on ischiopodites of third pereiopods only. First pleopod of first form male reaching cephalad to coxopodite of second pereiopod; no shoulder present on cephalic surface; central projection slightly longer than mesial process; mesial process with a longitudinal groove cephalad, and without an accessory spine, notch or prominence on caudal surface. Annulus ventralis with a caudally projecting prominence; (See fig. 3 for surface contour and configuration).

*Holotypic Male, Form I.*—Body subovate, slightly depressed. Abdomen narrower than thorax (9.5–10.7 mm in widest parts respectively). Width of carapace greater than depth in region of caudodorsal margin of cervical groove (10.7–9.4 mm).

Areola of moderate width (five times longer than broad) with a few scattered punctations (about three in narrowest part); cephalic section of carapace about twice as long as areola (length of areola about 32% of entire length of carapace).

\* Creaser (1933:5) pointed out the apparent intermediate position of *O. punctimanus* between the members of his Hylas Group, the Rusticus Group and the members of the Virilis Section. In spite of the somewhat distant relationship of *punctimanus* with the other members of the Hylas Group, it seems to have more in common with them than with any other single species or group. Therefore I am including it in the present discussion.

\*\* It is a pleasure to name this new species in honor of Mr. Lewis J. Marchand, formerly of the University of Florida, who has been a congenial companion on numerous collecting trips and who has aided me in many ways in my crayfish studies.

Rostrum with somewhat thickened margins slightly converging cephalad, and turning laterad at base, somewhat resembling that of *O. rusticus placidus*. Upper surface excavate. Lateral spines well developed and turned slightly dorsad. Acumen prominent with tip only slightly upturned. Subrostral ridges only moderately developed and barely visible in dorsal aspect near midlength of rostrum. A single row of setiferous punctations present along mesial side of marginal ridges extending cephalad onto the acumen.

Postorbital ridges well defined, grooved and terminating cephalad in heavy corneous spines. Suborbital angle absent. Branchiostegal spine acute but not prominent. Sinistral spine on side of carapace broken, and dextral spine divided (normally, a single acute spine present on either side of carapace). Surface of carapace bearing large prominent punctation particularly on dorsal portion of cephalic section; lateral surfaces of cephalic section granular.

Abdomen a little longer than carapace (23.3–21.7 mm).

Cephalic section of telson with two spines in each caudolateral corner.

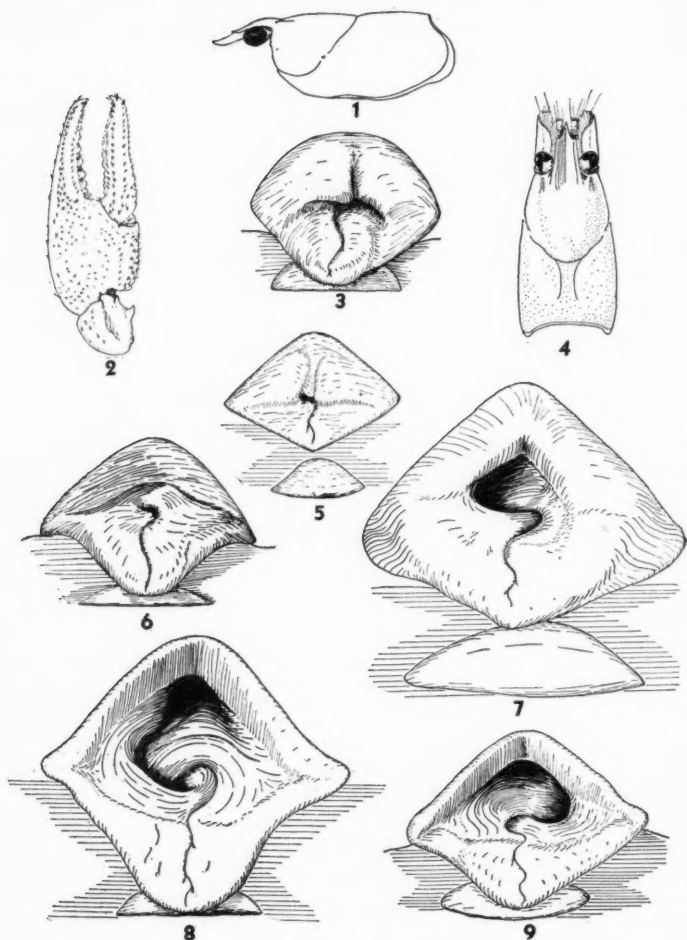
Epistome subtriangular in shape; no cephalomedian projection present.

Antennules of the usual form with a small spine present on ventral surface of basal segment.

Antennae extend caudad almost to cephalic margin of telson. Antennal scale of moderate width; outer portion broad and somewhat swollen, and terminating distad in a heavy spine; lamellar portion relatively narrow; cephalomesial margin evenly rounded.

Chela somewhat depressed with palm slightly inflated, all surfaces bearing setiferous punctations, more prominent above than below. Inner margin of palm with a row of seven or eight well defined tubercles; above this row a somewhat poorly defined one of six or seven tubercles (in some specimens there are indications of a third row; usually they are more irregularly placed proximad). Fingers only slightly gaping at base. Upper surface of immovable finger with a faint broad submedian ridge flanked by setiferous punctations; immediately mesiad of the faint ridge is a somewhat more prominent though narrower ridge which fades out at the base of the distal third of the finger. Lateral margin of finger with a moderately prominent ridge bearing a row of setiferous punctations. Mesial surface bearded at base, and bearing five or six prominent rounded tubercles between which are two or three smaller ones; distal two-fifths with minute denticles, and the usual strong corneous tubercle at base of distal third. Dactyl like immovable finger except mesial margin bears 10 rounded tubercles, no beard at base, and the large corneous tubercle absent at base of distal third. Lower surface of palm with a well defined spinous tubercle at base of dactyl.

Carpus of first pereopod longer than broad with a broad prominent longitudinal furrow above; otherwise surfaces relatively smooth with a few setiferous punctations. Mesial surface with a strong acute spine; distal upper mesial margin with a similar although somewhat smaller spine; lower surface with a very heavy mesiodistal spine; between it and the large spine on the mesial surface are two slightly smaller ones. Lower distolateral margin with another prominent corneous spine.



Figs. 1-9. 1. Lateral view of carapace, first form male, *O. marchandi*, type locality; 2. Upper surface of chela, first form male, *O. marchandi*, type locality; 3. Annulus ventralis of *O. marchandi*, type locality; 4. Dorsal view of carapace, first form male, *O. marchandi*, type locality; 5. Annulus ventralis of *O. propinquus propinquus*, Muncie, Vermilion Co., Illinois; 6. Annulus ventralis of *O. quadruncus*, one mile southwest of Middlebrook, Iron Co., Missouri; 7. Annulus ventralis of *O. punctimanus*, Mill Creek at Mineral Point, Washington Co., Missouri; 8. Annulus ventralis of *O. peruncus*, seven miles south of Fredericktown, Madison Co., Missouri; 9. Annulus ventralis of *O. hylas*, Piedmont, Wayne Co., Missouri.

Merus with a single large acute spine on upper distal surface; upper mesiodistal edge sub serrate. Lower laterodistal and mesiodistal angles each with a prominent spine. Lower surface with a mesial row of eight small spines and lateral margin with two prominent ones.

Hooks on ischiopodites of third pereopods only; hooks strong with proximal surfaces concave and bearing setae.

Maxillipeds and cephalic portion of sternum (i.e., between the first and fourth pereopods) hirsute.

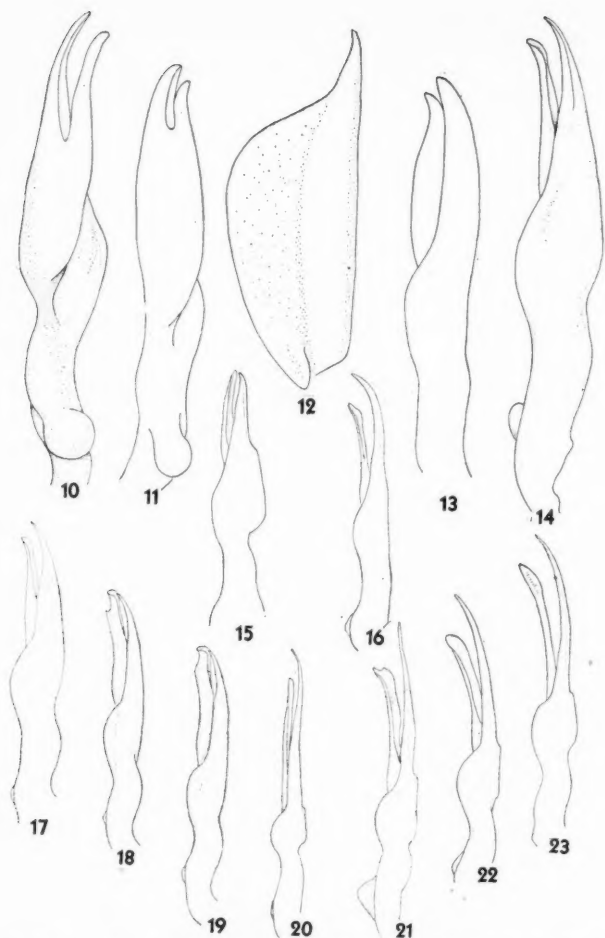
First pleopod reaching coxopodite of second pereopod when abdomen is flexed. Tip terminating in two distinct parts. Central projection corneous, slender, tapering and distally recurved. It is a little longer than the mesial process which is non corneous, trough-like and displaced laterad so as to lie caudad of the distal portion of the central projection. Viewed laterally the two terminals are subparallel.

*Paratypic Male, Form II.*—The second form male differs chiefly from the holotype in the shape of the rostrum, the margins of which are slightly excavated, not converging; the chela is weaker and the lateral margin distinctly keeled; a single well developed acute spine on either side of carapace. Hooks on ischiopodites of third pereopod knob-like. First pleopod with heavier terminals and non-corneous; otherwise similar to that of holotype. Other minor differences occur in the number of spines on several structures (e.g., lower lateral margin of merus with three spines instead of two, and only one spine between the large mesial spine and the large mediodistal spine of lower surface of carpus).

*Allotypic Female.*—Differs from the holotypic male in that the chelae are weaker and the tubercles are not so prominent; epistome more evenly rounded; no spines present between the large mesial spine and the mesiodistal spine on lower surface of carpus. Annulus ventralis with evenly rounded cephalic margin firmly fused with sternum, and the "free" caudolateral margins converging caudally to the median line forming a blunt rounded prominence; cephalic area broadly convex ventrad with a longitudinal fissure; cephalomedian depression poorly defined. Sinus originates near cephalic margin of annulus, extends slightly caudosinistrad, turns somewhat abruptly caudodextrad then gently caudosinistrad, then forming a broad curve turns caudodextrad, then back to the median line near the caudal margin of the annulus (See fig. 3). Sternum forms a broad arch over cephalic and cephalolateral surfaces of annulus.

*Measurements.*—Male (form I) Holotype: carapace, height 9.4, width 10.7, length 21.7 mm; areola, width 1.4, length 7.0 mm; rostrum, width 3.1, length 5.5 mm; abdomen, length 23.3 mm; right chela, length of inner margin of palm 5.7, width of palm 7.9, length of outer margin of hand 17.5, length of movable finger 10.8 mm. Allotypic Female: carapace, height 9.2, width 10.7, length 21.8 mm; areola, width 1.1, length 7.0 mm; rostrum, width 3.0, length 5.4 mm; abdomen, length 24.6 mm; right chela, length of inner margin of palm 4.5, width of palm 6.0, length of outer margin of hand 14.3, length of movable finger 9.0 mm.





Figs. 10-23. 10. Mesial view of first pleopod of first form male, *O. marchandi*, type Locality; 11. Mesial view of first pleopod of second form male, *O. marchandi*, type Locality; 12. Antennal scale of *O. marchandi*, type Locality; 13. Lateral view of first pleopod of first form male, *O. marchandi*, type Locality; 14. Lateral view of first pleopod of first form male, *O. marchandi*, type Locality; 15. Lateral view of first pleopod of first form male, *O. propinquus propinquus*, Muncie, Vermilion Co., Illinois; 16. Lateral view of first pleopod of first form male, *O. virilis*, Paris, Edgar Co., Illinois; 17. Lateral view of first pleopod of first form male, *O. marchandi*, type Locality; 18, 19. Lateral view of first pleopod of first form male, *O. quadruncus*, one mile south of Middlebrook, Iron Co., Missouri; 20. Lateral view of first pleopod of first form male, *O. hylas*, Piedmont, Wayne Co., Missouri; 21, 22. Lateral view of first pleopod of first form male, *O. peruncus*, seven miles south of Fredericktown, Madison Co., Missouri; 23. Lateral view of first pleopod of first form male, *O. punctimanus*, Mill Creek at Mineral Point, Washington Co., Missouri.

*Type Locality.*—A small, clear rocky stream of moderate current 3.2 miles southeast of Hardy, Sharp County, Arkansas on U. S. Hy. 63. The crayfish were collected from beneath stones along with another species which is either *Orconectes nais* (Faxon) or is closely related to it.

*Disposition of Types.*—The male holotype, the female allotype, and a second form male paratype are deposited in the United States National Museum (Nos. 82072-74). Of the remaining paratypes one male, form I, one male, form II, and a female are in the Museum of Comparative Zoology, a similar series is in the University of Michigan Museum of Zoology, and 11 males, form I, one male, form II, two females and two immature males are in my personal collection at the University of Virginia.

*Variation.*—The chief variations noted are in the rostrum and the first pereiopod. The margins of the rostrum may either be convergent, subparallel or concave. The outer margin of the chela in most of the specimens is distinctly keeled, and the tubercles along the inner margin of the palm may be in two or three irregular rows with scattered ones proximad. The extremes of variation in the armature of the carpus and merus are given in the descriptions above.

*Relationships.*—*Orconectes marchandi* has its closest affinities with the members of the Hylas Group of the Propinquus Section (Ortmann, 1931: 65-66), and seems to be more closely related to *O. quadruncus* (Creaser) than to any other member of the group. The first pleopod of the males and the annulus ventralis of the females are distinctly similar in the two species. At the same time these two structures resemble those of the three subspecies of *O. propinquus*. Creaser (1934: 5-6) has discussed the interrelationships of the species of the Hylas Group and has offered an explanation as to the cause of the distributional peculiarities. His discussion of the possible history of the group is as follows: "The original home of the *hylas* stock was in the Black River. It will be recalled that the Black River flows into the White River which has as a very peculiar crayfish fauna in other respects. From there the ancestral stock of *peruncus* was able to establish itself in the Big Creek on the far western side of the St. Francis drainage. This establishment may have occurred by virtue of stream capture. The species *peruncus* was rather widespread in the headwaters then existing in the St. Francis River. As the river expanded its headwater streams the older headwaters containing *peruncus* were ecologically shut off by deepening of the river and by the deposition of sediment. The species *quadruncus* meanwhile differentiated in these newly formed or newly found headwaters, which perhaps may have flowed into another drainage." (Creaser, 1934: 6).

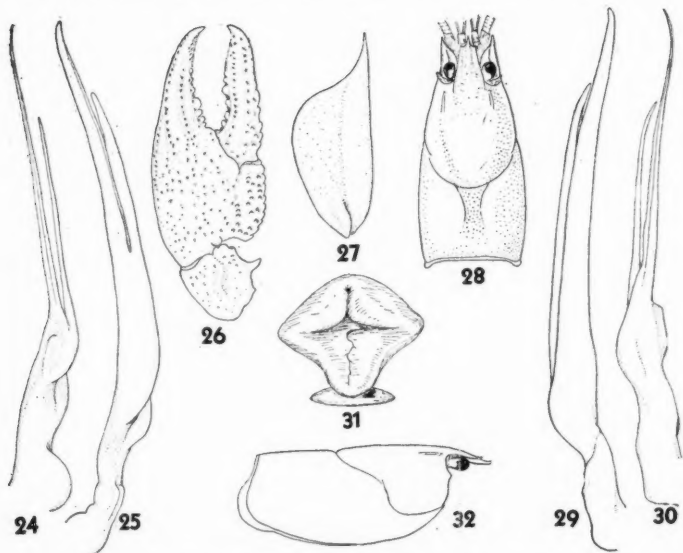
This explanation is based on a number of assumptions, at least one of which, in view of the discovery of *O. marchandi* in the Black River drainage, is questionable. If the close relationship between *O. marchandi* and *O. quadruncus* is an actuality, then some modification of Creaser's idea as to the evolutionary sequence must be made, and while I have no concrete proposal to offer, it does not seem amiss to reiterate that *O. marchandi* shows several striking resemblances to the members of the Propinquus Group, and that it is

at least possible that it more nearly resembles the ancestral stock than does *hylas*.

Regardless of which of these species is the most "primitive", anatomically *marchandi* and *quadruncus* are at one end of the series and *leptogonopodus* (see below), *hylas* and *punctimanus* at the other, with *peruncus*, in certain respects, lying between.

*Orconectes leptogonopodus* sp. nov.

*Diagnosis*.—Rostrum with lateral spines, margins somewhat thickened and slightly convex laterad. Areola about five times longer than broad with three to five punctations in narrowest part—length about 32% of entire length of carapace; postorbital ridges terminating cephalad in heavy corneous spines; sides of carapace devoid of spines; in male, hooks on ischiodites of third pereiopods only. First pleopod of first form male reaching cephalad to coxopodite of first pereiopod; shoulder present on cephalic surface; central projection decidedly longer than mesial process, setiform and straight almost to tip; mesial process slender and bent mesiad near tip. Annulus ventralis with caudally projecting tongue-like prominence; median longitudinal depression covered by mesial projections from the tranverse fold; however, the longitu-



Figs. 24-32. *Orconectes leptogonopodus*. 24. Mesial view of first pleopod of first form male; 25. Mesial view of first pleopod of second form male; 26. Upper surface of chela of first form male; 27. Antennal scale; 28. Dorsal view of carapace; 29. Lateral view of first pleopod of second form male; 30. Lateral view of first pleopod of first form male; 31. Annulus ventralis; 32. Lateral view of carapace.

dinal depression evident both cephalad and caudad of the projections (See fig. 31).

*Holotypic Male, Form I.*—Body subovate, depressed. Abdomen narrower than thorax (8.7–9.6 mm in widest parts respectively). Width of carapace greater than depth in region of caudodorsal margin of cervical groove (9.6–8.3 mm).

Areola moderately broad (five times longer than wide) with many prominent punctations (four in narrowest part); cephalic section of carapace 2.1 times as long as areola (length of areola about 32% of entire length of carapace).

Rostrum with thickened margins converging cephalad, and somewhat laterally convex at base. Upper surface punctate caudad and bearing a prominent median carina cephalad; carina flanked by a row of setiferous punctations. Lateral spines heavy and short, directed cephalodorsad. Acumen of moderate length and only slightly upturned. Subrostral ridges poorly developed, scarcely visible in dorsal aspect. A single row of setiferous punctations present on mesial side of marginal ridges extending cephalad on to the acumen.

Postorbital ridges prominent, grooved, and terminating cephalad in heavy corneous spines. Suborbital angle prominent but rounded. Branchiostegal spines minute. No lateral spines on side of carapace. Surface of carapace entirely punctate.

Abdomen longer than carapace (21.4–18.6 mm).

Cephalic section of telson with two spines in each caudolateral corner.

Epistome subovate, broader than long, a small cephalomedian projection present.

Antennules of usual form with a prominent spine on ventral surface of basal segment.

Antennae in holotype broken but in other specimens extend caudad from second to fourth abdominal segment. Antennal scale of moderate width; lateral portion broad and swollen, and terminating distally in a long, heavy, prominent spine; lamellar portion only slightly broader than swollen lateral part, evenly rounded mesiad.

Chela depressed but palm somewhat inflated; all surfaces bearing setiferous punctations. Inner margin of palm with a row of eight scale-like tubercles; above this row another of eight. Fingers slightly gaping at base. Upper surface of immovable finger with a prominent submedian ridge flanked by deep setiferous punctations; immediately mesiad of this ridge is another prominent one which is not discernible on distal third of finger; laterad of the first mentioned ridge is a less conspicuous ridge which extends along the basal half of finger; lateral margin with a broad keel bearing a row of deep setiferous punctations; opposable surface of finger with five or six rounded tubercles (the third from base largest) on proximal two-thirds; distal third bearing minute denticles, and the usual strong corneous tubercle at base of distal third much reduced. Upper surface of dactyl like immovable finger; mesial margin bearing

a row of five or six scale-like tubercles on proximal half; opposable margin with six or seven rounded tubercles (fourth from base largest). Lower surface of palm with two prominent tubercles at base of dactyl.

Carpus of first pereiopod longer than broad with a prominent longitudinal groove above; upper surface punctate laterad of groove and with a few scale-like tubercles mesiad of it; mesial surface with a strong median spike-like spine, proximad of which is a small tubercle; upper distal margin with two heavy rounded tubercles; lateral surface punctate; lower distal median margin with a strong acute spine, and lower distolateral margin with a prominent tubercle.

Merus with two spines on upper distal surface; upper mesiodistal edge with several small tubercles. Lower laterodistal angle with a prominent tubercle; lower mesiodistal angle with a strong spine. Lower surface with a mesial row of eight or nine spines and a lateral row of three.

Hooks on ischiopodite of third pair of pereiopods only; hooks strong with proximal surface concave and bearing setae.

Maxillipeds and thoracic portion of sternum hirsute.

First pleopod reaching coxopodite of first pereiopod, terminating in two parts. Central projection corneous, extremely slender, straight, only slightly recurved at tip. Mesial process decidedly shorter, non-corneous, slender and curved mesiad near tip. Prominent shoulder present on cephalic surface at base of terminal elements.

*Paratypic Male, Form II.*—The second form male paratype differs from the holotype in that the carina on the rostrum is not so prominent; the subrostral ridges are distinctly visible in dorsal aspect; epistome is without a cephalomedian projection; antennae extend caudad to fourth abdominal segment. There are slight differences in tubercle counts, e.g., inner margin of palm with six or seven tubercles and with a row of six above. Hooks on ischiopodites of third pereiopod reduced and rounded. First pleopod with much heavier terminals, neither of which is corneous; shoulder absent from cephalic surface at base of terminal elements.

*Allotypic Female.*—The allotypic female differs in only a few minor details from the holotypic male. The chelae are noticeably weaker (see measurements), and there are slight differences in the number of tubercles present on various parts. Annulus ventralis with evenly rounded cephalic margin fused with sternum; produced caudad to form a free tongue-like prominence; cephalic half forming two rounded caudally projecting folds overhanging (in ventral view) the fossa; folds meeting on midventral line for a short distance leaving an opening cephalad; tongue-like caudal portion bearing an undulating sinus along median line extending from caudal margin of annulus cephalad, and disappearing beneath the overhanging folds.

*Measurements.*—Male (form I) Holotype: carapace, height 8.3, width 9.6, length 18.6 mm; areola, width, 1.2, length 6.0 mm; rostrum, width 3.0, length 4.1 mm; abdomen, length 21.4 mm; right chela, length of inner margin of palm 5.6, width of palm 7.5, length of outer margin of hand 15.4, length of movable finger 9.7 mm. Allotypic Female: carapace, height 8.0, width 9.6, length 19.4 mm; areola, width 1.3, length 6.4 mm; rostrum, width 3.1, length

4.3 mm; abdomen, length 23.1 mm; right chela, length of inner margin of palm 5.0, width of palm 6.6, length of outer margin of hand 14.2, length of movable finger 9.0 mm.

*Type Locality*.—McKinney's Creek, 4.7 miles northeast of Hatfield, Polk County, Arkansas on U. S. Hy. 71. This is a small, shallow, rocky, clear stream, and the crayfishes were found in shallow excavations beneath stones. In the same locality *Orconectes longimanus* (Faxon) was common.

*Disposition of Types*.—The male holotype, the female allotype, and a male, form II, paratype are deposited in the United States National Museum (No. 82262). Of the remaining paratypes one male, form I, one male, form II, and a female are in the Museum of Comparative Zoology, a similar series in the University of Michigan Museum of Zoology, and one male, form I, 16 males, form II, 22 females, two immature males, and one immature female are in my personal collection at the University of Virginia.

*Variation*.—The variations existing in the specimens I have at hand are hardly worthy of mention. As usual there are slight differences in the armature of the various parts. In a few specimens the keel on the rostrum is very much reduced, and in others it is better developed than in the holotype.

*Relationships*.—*Orconectes leptogonopodus* has its closest affinities with *Orconectes hylas*; this relationship is demonstrated in the long slender terminal elements of the first pleopod of the males and the prominent shoulder on the cephalic margin of the appendage at the base of these terminals. Further the similarity in structure of the annulus ventralis of the two species is well marked. (See the discussion of the relationships of *O. marchandi*).

#### KEY TO THE SPECIES OF THE HYLAS GROUP

(Based on First Form Male)

1. Shoulder present on cephalic margin of first pleopod; terminal elements decidedly unequal in length, central projection always longer than mesial process. Central projection reaching cephalad to coxopodite of first pereopod .....3
- 1' Shoulder absent on cephalic margin of first pleopod; terminal elements subequal in length or central projection slightly longer than mesial process. Central projection reaching to coxopodite of second pereopod .....2
- 2(1') Terminal elements of first pleopod subequal in length; mesial process bearing an accessory spine, notch or prominences on its caudal surface; hooks present on ischiopodites of third or third and fourth pereopods .....  
.....*Orconectes quadruncus* (Creaser)
- 2' Central projection of first pleopod extending beyond tip of mesial process; mesial process bearing no spine, notch or prominence on its caudal surface; surface smooth; hooks present on ischiopodites of third pereopods only .....  
.....*Orconectes marchandi* sp. nov.
- 3(1) Mesial process of first pleopod neither broadened nor flattened near distal end; both mesial process and central projection straight throughout most of their lengths; extreme distal portion of central projection curved slightly caudad .....5

- 3' Mesial process somewhat broadened and flattened near distal end; both terminals somewhat curved caudad .....4
- 4(3') Hooks present on ischiopodites of third and fourth pereopods; free margin of dactyl of chela with a row of two or three tubercles on proximal portion .....*Orconectes peruncus* (Creaser)
- 4' Hooks on ischiopodites of third pereopods only; free margin of dactyl of chela with a row of seven or eight tubercles .....*Orconectes punctimanus* (Creaser)\*
- 5(3) Upper surface of rostrum with a median carina; no lateral spines present on carapace in region of cervical groove .....*Orconectes leptogonopodus* sp. nov.
- 5' Upper surface of rostrum without a median carina; lateral spines present on carapace in region of cervical groove .....*Orconectes hylas* (Faxon)

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\* See footnote page 140.



## Snails of the Sierra Ancha, Arizona

S. Stillman Berry  
Redlands, California

From the 17th to the 19th of May, 1929, Mr. A. M. Strong paid a brief visit to the Sierra Ancha, Gila County, Arizona, in the course of which he made a small collection of land-snails. As his own field of interest chiefly concerns the marine fauna, he generously transmitted these specimens to me for study. They have proven to be of considerable interest, for not only does Mr. Strong appear to be the pioneer collector in the Sierra Ancha, but this range 1) is located in a part of Arizona the snail fauna of which practically in its entirety is unknown, and 2) its position is conceivably of considerable importance from the geographic point of view. Previous experience in Arizona leads one to suspect that collecting in an unexplored mountain range would very certainly result in the discovery of a certain number of species not previously known. In the present instance, in spite of the cursory nature of the exploration, we are not disappointed.

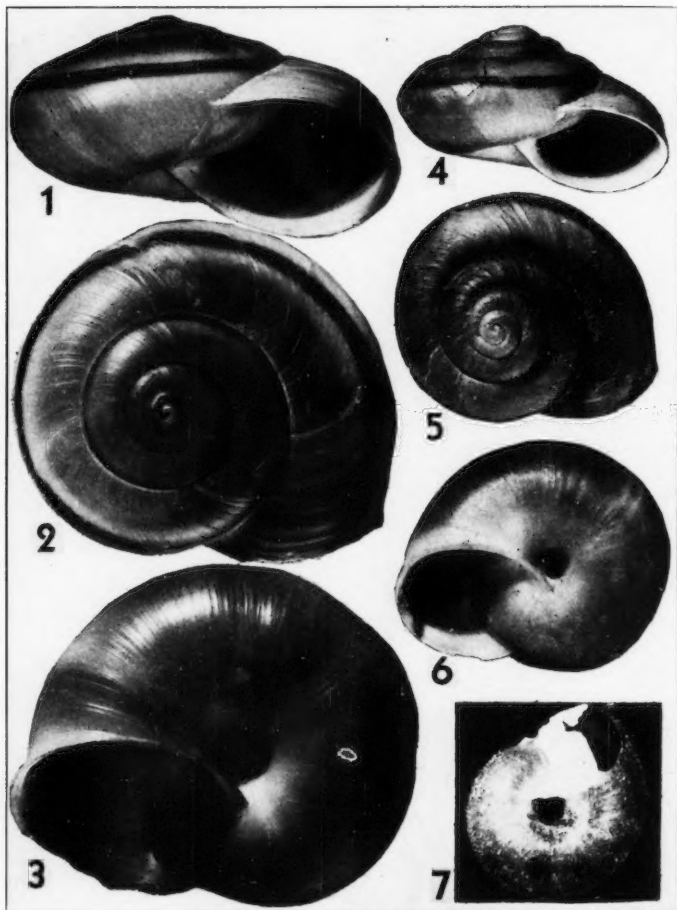
The Sierra Ancha is situated northeast of Roosevelt Reservoir on Salt River, its general trend being northwest to southeast. Gila County covers a large area, but it is considerably northwest of the regions in southern and eastern Arizona which were the scene of the inspiring pioneer explorations of the late James H. Ferriss and his associates. At any rate, I have found but a single previously published molluscan record for the whole of Gila County, this being the *Sonorella* (*S. rooseveltiana* Berry, 1917:14) taken by Willett at Roosevelt.

Mr. Strong collected only at two stations, namely, 1) Three miles north of Reynolds Creek near Pueblo mine, north side of Sierra Ancha, where he found *Sonorella strongiana* n. sp. and 2) Reynolds Creek, three miles above ranger station on Pleasant Valley Road, Reynolds Falls Asbestos Mine property, Sierra Ancha (Alt. ca. 6,000 ft.), where he took *Sonorella anchana* n. sp., *Zonitoides aboreus* (Say), and *Discus cronkhitei* (Newcomb). Descriptions of the two new species together with a brief discussion of their apparent relationships follow.

### 1. *Sonorella strongiana* n. sp.

Figs. 1-3, 8.

*Description:* Shell large for the genus, depressed-conic; whorls a little more than five, moderately convex, increasing evenly at first and quite gradually, but the last whorl widening rapidly, fairly tumid, and at last quite strongly descending to the aperture; base moderately tumid; umbilicus open, funicular, permeable to the apex, contained a little more than 7 times in the major shell-diameter. Aperture elliptic-lunate, strongly oblique; peristome hardly thickened on the single specimen seen, barely everted above and only



Figs. 1-7: 1-3. *Sonorella strongiana* n. sp., three views of holotype ( $\times 2+$ ); 4-6. *Sonorella anchana* n. sp., three views of holotype ( $\times 2+$ ); 7. *Sonorella anchana* n. sp., juvenile paratype 6904e of  $3\frac{1}{4}$  whorls (sutural measurement) in basal view, showing pelage and ruptured epiphragm (approx.  $\times 3.6$ ). Figs. 1-6 are from photographs by A. E. Burns of Oakland; fig. 7 is from a photograph by M. W. Williams of La Jolla, California.

narrowly so below, with only a very moderate columellar flare which impinges but little on the umbilicus.

Sculpture obsolete on first half-whorl or at best represented by a few weak wavy wrinkles; remainder of embryonic shell very closely and finely wrinkled beneath a heavier sculpture of numerous rounded granules which soon tend to coalesce into two series of more or less interrupted lines, the one decurrent and more commonly passing down *from* the suture, the other recurrent and passing down *to* the suture, but the two often intersecting one another over much of the whorl, particularly on the convexity; neanic whorls at first granular, but the granules soon become obsolete and the remainder of the mature shell is quite devoid of sculpture of any kind except the numerous and usually fine but irregular and occasionally rather coarse growth-lines.

Periostracum highly polished, especially on the base; spire Wood Brown, base between Avellaneous and Wood Brown, paler around umbilicus; shell encircled above the periphery by a very bright conspicuous band of Liver Brown about 2 mm. wide, bordered below by a slightly wider pale area of Tilleul Buff and above by a somewhat narrower band of the same tone.

*Measurements of holotype:* Max. diam. 26.0 mm, min. diam. 21.3 mm, alt. 14.6 mm, diam. umbil. 3.6 mm. Whorls  $5\frac{1}{8}$ .

*Holotype:* Cat. No. 6907 Berry Collection.

*Type Locality:* Three miles north of Reynolds Creek near Pueblo Mine, north side of Sierra Ancha, Gila County, Arizona; one mature specimen, A. M. Strong, May 1929.

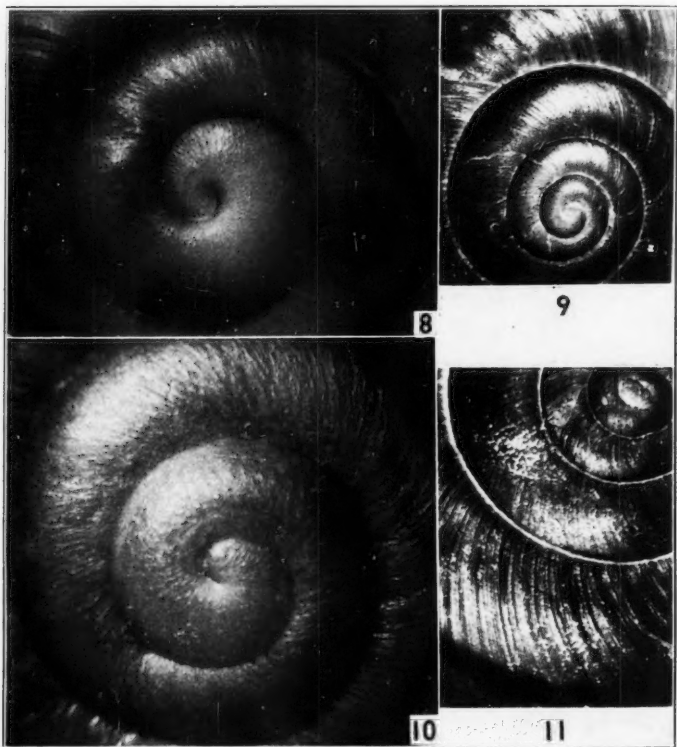
*Remarks:* This is an extremely large and handsome *Sonorella*, but its shell not strikingly differentiated and were it not for the geographic position occupied, one might be forgiven a little hesitation in describing it as distinct. Its near relationships appear to be with the *ashmuni-hachitana* series so far as can be inferred from such features as shell-texture and embryonic sculpture. The anatomy of the reproductive system would be conclusive in the matter but unfortunately the animal was not preserved. Among species and races previously described, *S. marmorarius imula* of the Santa Catalina Mountains (Pilsbry & Ferriss 1919:297, pl. 3, figs. 7, 7a) may be cited as one form which seems particularly close in its shell-characters, but *strongiana* appears to have a more clear-cut and elegant development of the embryonic sculpture, differs in color, and has a more highly polished surface than any specimens of *marmorarius* or its races seen by me. Shells of *S. tortillita* of the Tortillita Mountains (op. cit., p. 299, pl. 5, figs 4-4b) also somewhat suggest the present species, but the umbilicus is decidedly more open in *strongiana*, the embryonic sculpture closer and more geometric, and the subsequent papillation both finer and sooner to disappear.

It is a pleasure to associate with so beautiful a snail the name of the well-known conchologist Mr. A. M. Strong of Balboa, California, its discoverer.

2. *Sonorella anchana* n. sp.

Figs. 4-7, 9, 10, 12-16.

*Description:* Shell of only moderate size, depressed-conic; whorls  $4\frac{1}{2}$  to  $4\frac{7}{8}$ , convex, increasing quite slowly at first, the last widening rapidly, and slightly descending above near the aperture; base moderately tumid, the narrow steep-walled umbilicus permeable to the apex and contained on the average about  $8\frac{1}{2}$  ( $7\frac{1}{2}$  to  $9\frac{1}{4}$ ) times in the major diameter of the shell. Aperture elliptic-lunate (very much as in *S. odorata*), oblique; peristome a



Figs. 8-11: 8. *Sonorella strongiana* n. sp., microphotograph of apical whorls of holotype (approx. 14.5 $\times$ ); 9. *Sonorella anchana* n. sp., microphotograph of upper surface of paratype No. 6904d (approx. 3.9 $\times$ ); 10. *Sonorella anchana* n. sp., microphotograph of apical whorls of holotype (approx. 10.4 $\times$ ); 11. *Sonorella odorata* Pilsbry & Ferriss, microphotograph of upper surface of 7913a (approx. 4.4 $\times$ ). Figs. 8 and 10 are from photographs by A. E. Burns of Oakland; figs. 9 and 11 are from photographs by M. W. Williams of La Jolla, Calif.

trifle thickened, narrowly expanded throughout, widening into a moderate flare at the columella to cover merely the edge of the umbilicus.

First half-whorl sculptured with low irregular radial waves which pass into an exceedingly fine close anastomotic wrinkling, covering the entire surface, overlying which is a system of distinct, well separated, forward-pointing, linear papillations arranged decurrently and becoming in the post-embryonic stage smaller, more rounded, and in very young and unworn shells bearing a pelage of short, slender, pointed, hair-like periostracal processes, (fig. 7) which papillations gradually become more and more indistinct until they are practically obsolete on the last whorl. Spiral sculpture wanting. Growth-lines fine and close but not very regular. Base unsculptured except for the fine growth-lines and the microscopic wrinkling, here less developed than above, with perhaps a few faint traces of papillation.

Periostracum not polished, but with a somewhat satiny luster, duller above. Upper surface Buffy Brown, sometimes paling to Dark Olive Buff on spire; base Wood Brown (Buffy Brown in younger shells); shell encircled above the periphery by a simple narrow distinct band of Bister about 1 mm. wide.

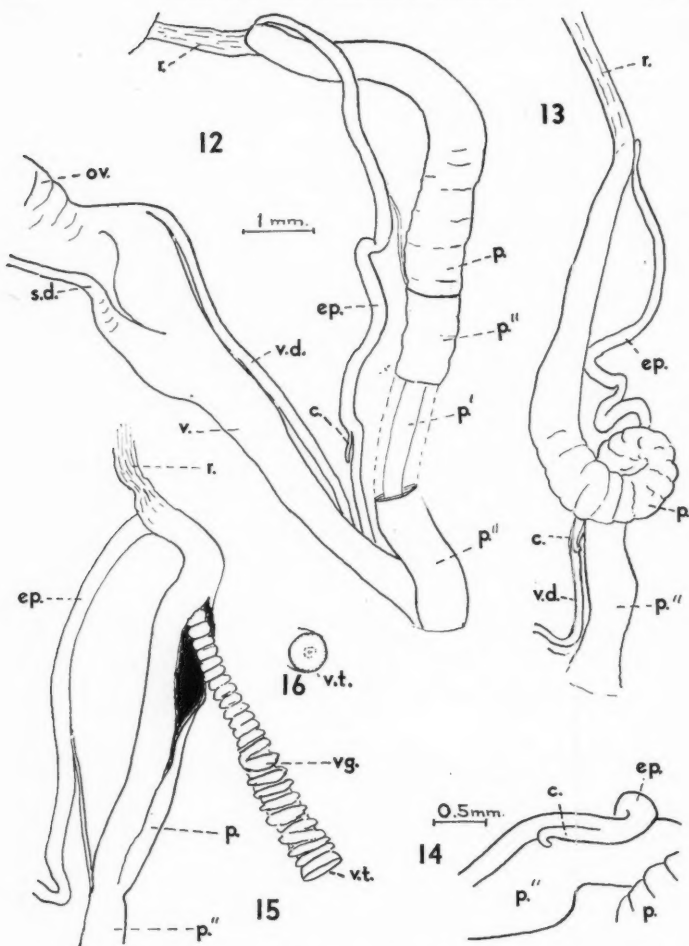
Penis moderately long (ca. 10 to 10.5 mm.), thicker in lower median portion, with more or less distinctly convoluted walls, in some examples quite strongly coiled (Fig. 13), the basal portion sheathed (Fig. 12); retractor very long in its relaxed state, as thick as the penis at this point when contracted. Epiphallus long, slender, more or less convoluted, terminating in a short but well-developed obtuse caecum (Figs. 12-14). Verge large, filling the penial chamber for nearly the entire length of the portion proximad to the sheathed part, and most remarkable in form, being cylindric, somewhat narrow at first, but increasing in diameter to nearly the capacity of the chamber, whilst strongly concentrically folded or ridged in concentric rings, thus curiously suggestive of a crinoid stem in general aspect except for the presence of occasional irregularities (Fig. 15); termination abrupt, the last segment resembling a flattened and slightly concave disk with a minute, pore-like dot on a slightly raised small round boss in the center, doubtless representing the opening of the lumen (Fig. 16).

The following measurements are given in millimeters.

	Max. Diam.	Min. Diam.	Altitude	Diameter Umbilicus	Number Whorls
6904. paratype .....	18.5	15.4	10.6	2.3	4.7
paratype .....	18.4	15.3	10.6	2.0	4.7
paratype .....	17.6	14.4	10.2	2.3	4.9
6903. holotype .....	17.4	14.4	10.3	2.3	4.8
6904. paratype .....	17.4	14.4	9.7	2.0	4.5
paratype .....	17.3	14.4	10.1	2.0	4.7
paratype .....	17.2	14.3	9.6	2.0	4.6
paratype .....	16.6	14.1	10.0	1.8	4.7
paratype .....	16.5	13.5	9.4	1.8	4.7

*Holotype:* Cat. No. 6903 Berry Collection.

*Paratypes:* Cat. No. 6904 Berry Collection; others to be deposited in the



Figs. 12-16: 12. *Sonorella anchana* n. sp., distal portion of ♂-♀ system of paratype No. 6904a (camera outline); 13. ♂ ducts of No. 6903, holotype (camera outline); 14. portion of ♂ system of holotype more greatly enlarged to show epiphallic caecum (camera outline); 15. portion of ♂ system in paratype No. 6904c, with penial chamber opened to permit extrusion of verge; 16. oblique view of distal extremity of verge of same preparation (same scale).

Abbreviations: c.—epiphallic caecum, ep.—epiphallus, ov.—oviduct, p.—convoluted portion of penis, p'.—portion of penis exposed by cutting and retraction of sheath, p''.—sheathed portion of penis, r.—penis retractor, s.d.—spermatophoric duct, v.—vagina, v.d.—vas deferens, vg.—verge, v.t.—termination of verge.

collections of the Museum of Northern Arizona, United States National Museum, and the private collection of A. M. Strong.

*Type Locality:* Reynolds Creek, three miles above ranger station on Pleasant Valley Road, Reynolds Falls Asbestos Mine property, Sierra Ancha, Gila County, Arizona, Alt. ca. 6,000 ft.; 13 adults, 11 immature, all living, A. M. Strong, May 1929.

*Remarks:* Interspecific taxonomy in *Sonorella* is based less upon the shell-features usually relied upon in the study of helicoid snails than upon the detailed anatomy of the reproductive apparatus. Nevertheless *S. anchana* is quite distinct in its conchological features and I know but one previously described species which closely resembles it in color and form. This is the remarkable *odorata* Pilsbry & Ferriss (1919:285, text figs. 1a-d, pl. 3, figs. 1-4) from the Santa Catalina Mountains. The differences lie mainly in that *anchana* is smaller, more compactly coiled, a little lighter in color, the microscopical periostracal wrinkling is very much finer, and I find no evidence of the traces of spiral striation which are often quite distinct on the body-whorl of *odorata* (Fig. 11). Furthermore the latter species is not described as possessing a hairy shell, although I cannot but suspect that the examination of fresh unworn immature specimens will reveal that it has such. Pilsbry and Ferriss described the surface ornamentation of *odorata* as "minutely granular," probably because a sufficiently high magnification was not used upon it. Actually it is not at all granular, in the manner, for instance, that one observes in *granulatissima* Pilsbry (1902:32, 1905:262). Rather, as in *anchana* we find a system of very fine waves or wrinkles, which in *odorata* are larger than in *anchana*, less anastomosing, much more regular, and over much of the shell show a quite definite alignment perpendicular to the growth-wrinkles, while in *anchana* such alignment as we can make out is apt to be quite the other way.

Although I lack extensive comparative material in *Sonorella*, I am fortunate in having at hand three lots of *odorata* which have been made the basis of the foregoing comparisons. These are all from the Santa Catalina Mountains, Arizona, and are as follows:

Berry Coll.	No. Specimens	Locality	Collector	Date
5402	4 (paratypes)	Head of Alder Cr. Cn.	J. H. Ferriss	—
7913	5	Alt. 7700 ft., Soldiers Camp	L. H. Cook	Aug., 1934
7914	11	Alt. 7700 ft., Summerhaven, Upper Sabino Cn.	L. H. Cook	Aug. 10-18, 1934

The Soldier's Camp shells run appreciably larger than the other lots, while those from Summerhaven are much more distinctly spirally striate.

*S. clappi* Pilsbry & Ferriss (1915:397) has a very fine microscopic sculpture of the general type I have described, in this respect rather resembling a finer, more delicate, and somewhat more granular edition of *odorata*. *S. ferrissi*



Pilsbry (1915:368) is yet another species with periostracal sculpturing of somewhat the same character, although so very minutely carried out that it is difficult to compare the finer details. The form and color of the shell are, on the contrary, conspicuously different.

The near neighbor, *rooseveltiana* Berry (1917:14; Pilsbry & Ferriss, 1919: 314, pl. 6, figs. 9-9b), is entirely different in surface texture, different in embryonic sculpture, and does not appear to be hirsute when young. It clearly does not belong in the same group.

Hairiness of shell in the juvenile stages has been described for several species of *Sonorella*, notably *virilis leucura* Pilsbry & Ferriss (1910a:72), *micra* Pilsbry & Ferriss (1910a:75), *dragoonensis* Pilsbry & Ferriss (1915:369, 370), *apache* (especially hirsute) Pilsbry & Ferriss (1915:371), *bartschi* Pilsbry & Ferriss (1915: 384, 385), *vespertina* Pilsbry & Ferriss (1915:414), and *anchana* n. sp. To these I can likewise add *ferrissi* Pilsbry (1915:368), which similarly possesses short, slender, acute periostracal "hairs" well developed in younger stages, both above and below, over the entire shell. This holds true even of the embryo and it seems not impossible that fresh unworn material would reveal their presence on the mature body-whorl as well, for I do occasionally detect a trace of them there even in my specimens. They are easily rubbed off, and appear to be especially fugitive on the embryonic shell, on the base of the whorls, and on the upper surface of the body-whorl. They must often be brushed away in cleaning dirt from the shells, but even in the case of mature examples the protection afforded by the very deep suture and the umbilicus will enable some of the structures to persist. Pilsbry's failure to mention them must have been a simple oversight, as so close an observer as he could hardly have missed seeing them. The specimens before me are from Pilsbry and Ferriss Station 10, Tweed Amphitheatre, Dragoon Mountains (Pilsbry, Ferriss, & Daniels coll., 1910). From the published information, supplemented by the examination of such specimens as have been accessible to me, I am not disposed to consider that any of the other hirsute species mentioned are very close allies of *anchana*, with the single exception of *dragoonensis*, which unfortunately I have not seen. All the rest exhibit conspicuous differences either in the shell or the reproductive system or both.

The ♂-♀ apparatus of *anchana* seems superficially about as much like that of *S. o. marmoris* Pilsbry & Ferriss (1919:288, fig. 2) as any I have seen figured, but the epiphallic caecum is longer and the retractor considerably heavier. The epiphallic caecum recalls that of *dragoonensis* as figured (Pilsbry & Ferriss 1915: pl. 11, fig. 4), but the penis is longer and very different in shape. The conspicuous and strangely formed verge (Fig. 15) is nearly unique as far as I can ascertain from a search of available literature. The only description or figures I can find which appear to suggest anything at all comparable are those of *granulatissima* Pilsbry & Ferriss (1910:500), which is pictured as "short, cylindric, truncate at the end, and coarsely wrinkled," and still more so those of *danielsi* Pilsbry & Ferriss (1910:502), which is described as "somewhat similar to the latter but longer, — a long cylindric papilla which

is abruptly truncate at the end and wrinkled." The genitalia of these species do not otherwise, however, appear very similar to those of *anchana*. The verge in such species as *odorata* and *dragoonensis* is entirely different, being shown as obtusely conic or rounded at the end, and sometimes with more or less definitely longitudinal corrugation.

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- 1905—Mollusca of the southwestern states, I: Urocoptidae; Helicidae of Arizona and New Mexico. *Proceedings Academy Natural Sciences Philadelphia* 57[1905]:211-290, 8 text figs., pls. 11-27.
- AND J. H. FERRISS 1910—Mollusca of the southwestern states, III: The Huachuca Mountains, Arizona. *Proceedings Academy Natural Sciences Philadelphia* 61 [1909]:495-516, text figs. 1-11c, pls. 19-22.
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- 1915—Mollusca of the southwestern states, VII: The Dragoon, Mule, Santa Rita, Baboquivari, and Tucson Ranges, Arizona. *Proceedings Academy Natural Sciences Philadelphia* 67:[1915]:363-418, text figs. 1-8, pls. 8-15.
- 1919—Mollusca of the southwestern states, IX: The Santa Catalina, Rincon, Tortillita and Galiuro Mountains. X: The mountains of the Gila headwaters. *Proceedings Academy Natural Sciences Philadelphia* 70[1918]:282-333, text figs. 1-16, pls 3-7.

## North American *Plutellus* and *Megascolides* with Synonymical Notes (Annelida, Oligochaeta)

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The truly endemic North American earthworms, though they constitute only a small part of the total earthworm population, are almost all representatives of the family Megascolicidae. This family, a very ancient one, has spread widely throughout the tropics and the Southern Hemisphere and is there represented by a very rich fauna. North American members of the family, with the exception of a few peregrine species of tropical origin, belong to the genera *Diplocardia*, *Plutellus*, and *Megascolides*. *Diplocardia*<sup>1</sup> is considered a very primitive genus, constituting a group of indigenous species which occur throughout the Midwest and South as well as the Great Basin, Lower California and Mexico, where the genus presumably originated as early as the Jurassic and spread northward.<sup>2</sup> Because of the fact that the few persons who have worked on North American earthworms have done most of their work in the Midwest, the *Diplocardia* are relatively better known than *Plutellus* and *Megascolides*. West of the Rockies, the native earthworm fauna falls in the genera *Plutellus* and *Megascolides* and is very much richer in forms than a review of the literature would indicate.

The genotype of *Plutellus*, *Plutellus heteroporus* Perrier, was described in 1873 from two specimens collected in Pennsylvania more than 50 years earlier and oddly enough has never been recorded since, nor has any other species of this genus been collected in the eastern United States. In 1892, Benham described a species which he ascribed to the genus *Plutellus* from Queen Charlotte Is. Eisen (1894 and 1900) described Californian species of a new genus, *Argilophilus*, which, though representing a distinct group of species (perhaps of subgeneric rank) has since been united with *Plutellus*. Michaelsen (1921) described a closely related species, also Californian.

*Megascolides* was described from Australasia in 1878 and until 1897 all the species came from that region. Smith's description of *M. americanus* in that year was therefore of considerable interest. This genus, like *Plutellus*, presumably originated in Australia and spread by way of Siberia and Alaska to the Pacific Coast. Smith's (1897 and 1936) and Altman's (1937) papers on Oregon and Washington worms describe a number of species in these two genera, but the present authors' studies indicate that there is a wealth of undescribed material in this region. One species of *Plutellus* has been described from Guatemala<sup>3</sup> and many species of *Plutellus* and *Megascolides* have been described from Australia, India and Tasmania.

1 GARMAN, H.—Bull. Ill. State Lab. Nat. Hist., Vol. 3, pp. 47-77, 1888.

2 MICHAELSEN, W.—Geographische Verbreitung der Oligochaeten. Berlin. 1903.

3 *Plutellus hyalinus* Eisen: Proc. Cal. Acad. Sci., Ser. 3, Vol. 2, p. 163, 1900.

*Plutellus* and *Megascolides* both are more characteristic of unbroken soil and uninhabited areas than they are of urban or intensively cultivated environments where they are quickly replaced by the more adaptable Lumbricidae. Field recognition of this group of worms is made easy by their tendency to contract upon disturbance, becoming short and turgid in contrast with the flexuous wriggings of a disturbed Lumbricid. The anterior position of the clitellum, which begins with or in front of the fourteenth somite, is also readily noted in the field. The coloration is pale, sometimes marbled with purple or grey in *Plutellus*, and the clitellum is usually some shade of yellow or tan. The *Megascolides* are large worms, *M. wellsi* Alt. reaching over a foot in length and one-half inch in diameter. *Plutellus* are smaller, two to six inches.

The authors, being located in what appears to be a center of distribution of these worms, have accumulated considerable material, much of which belongs to apparently undescribed species. It seems expedient, in view of the present condition of the nomenclature of this group, to present the following synonymical study before proceeding with descriptions of new species, analyses of the phylogenetic relationships of the species and varieties, or distributional studies.

#### Genus PLUTELLUS E. Perrier

*Plutellus* Perrier: Arch. Zool. Exp. et Gen., vol. 2, p. 250, 1873.

#### PLUTELLUS HETEROPORUS Perrier

*Plutellus heteroporus* Perrier: Arch. Zool. Exp. et Gen., vol. 2, p. 250, figs. 1-3, 1873.

*Plutellus heteroporus* Perrier: Benham, Proc. Zool. Soc. London, pp. 137-141, 1892.

*Megascolides heteroporus* (Perrier): Beddard, Monogr. Oligochaeta, p. ??, 1895.

*Plutellus heteroporus* Perrier: Michaelsen, Oligochaeta, Das Tierreich, 10 Lief., XXIX plus 575 pp., p. 174, Berlin, 1900.

Type locality: Pennsylvania.

#### PLUTELLUS PERRIERI Benham

*Plutellus perrieri* Benham: Proc. Zool. Soc. London, pp. 136-141, figs. 1-4, 1892.

*Megascolides perrieri* (Benham): Beddard, Monogr. Oligochaeta, p. 496, Oxford, 1895.

*Plutellus perrieri* Benham: Michaelsen, Oligochaeta, Das Tierreich, 10 Lief., XXIX plus 575 pp., p. ??, Berlin, 1900.

Type locality: Queen Charlotte Is., B. C.

#### PLUTELLUS MARMORATUS (Eisen)

*Argilophilus marmoratus ornatus* Eisen plus *A. m. papillifer* Eisen: Zoe, vol. 4, p. 253, 1893.

*Argilophilus m. ornatus* Eisen plus *A. m. papillifer* Eisen: Mem. Cal. Acad. Sci., vol. 2, no. 3, pp. 53, 55, 1894.

*Megascolides ornatus* (Eisen) plus *M. papillifer* (Eisen): Beddard, Monogr. Oligochaeta, p. 495, Oxford, 1895.

*Argilophilus marmoratus* Eisen plus *A. m. collinus* Eisen: Proc. Cal. Acad. Sci., ser. 3, vol. 2, p. 163, 1900.

*Plutellus marmoratus* (Eisen): Michaelsen, Oligochaeta, Das Tierreich, 10 Lief., XXIX plus 575 pp., p. 166, Berlin, 1900.

Type locality: San Francisco Bay Region, Cal.

#### PLUTELLUS MARMORATUS (TYPICUS) (Eisen)

*Argilophilus marmoratus ornatus* Eisen: Zoe, vol. 4, p. 253, 1893.

*Argilophilus marmoratus ornatus* Eisen: Mem. Cal. Acad. Sci., vol. 2, no. 3, p. 53, pls. 18-27 and pl. 28 figs. 125-130, 1894.

- Megascolides ornatus* (Eisen): Beddard, Monogr. Oligochaeta, p. 495, Oxford, 1895.  
*Plutellus marmoratus (typicus)* (Eisen): Michaelsen, Das Tierreich, Oligochaeta, 10 Lief., XXIX plus 575 pp., p. 166, Berlin, 1900.  
*Plutellus marmoratus* (Eisen): Michaelsen, Arkiv för Zoologi, vol. 13, no. 19, pp. 10-12, pl. 1, figs. 4-6, 1921.  
Locality: Santa Rosa, Cal. and northward.

PLUTELLUS MARMORATUS PAPILLIFER (Eisen)

- Argilophilus marmoratus papillifer* Eisen: Zoe, vol. 4, p. 253, 1893.  
*Argilophilus m. papillifer* Eisen: Mem. Cal. Acad. Sci., vol. 2, no. 3, p. 55, pl. 28, figs. 131-132 and pl. 29, 1894.  
*Megascolides papillifer* (Eisen): Beddard, Monogr. Oligochaeta, p. 445, Oxford, 1895.  
*Plutellus marmoratus papillifer* (Eisen): Michaelsen, Das Tierreich, Oligochaeta, 10 Lief., XXIX plus 575 pp., p. 166, Berlin, 1900.  
*Plutellus papillifer* (Eisen): Michaelsen, Arkiv för Zoologi, vol. 13, no. 19, pp. 10-11, pl. 1, figs. 9-10, 1921.  
Locality: Southern part of that of the species, i.e., south of Santa Rosa, Cal.

PLUTELLUS MARMORATUS COLLINUS (Eisen)

- Argilophilus marmoratus collinus* Eisen: Proc. Cal. Acad. Sci., ser. 3, vol. 2, p. 163, pl. 12, figs. 118-121, 1900.  
*Plutellus collinus* (Eisen): Michaelsen, Oligochaeta, Das Tierreich, 10 Lief., XXIX plus 575 pp., p. 167, Berlin, 1900.  
Locality: Napa, Marin and San Marino Counties, California.

PLUTELLUS SIERRAE Michaelsen

- Plutellus sierrae* Michaelsen: Arkiv för Zoologi, vol. 13, no. 19, pp. 9-10, pl. 1, figs. 7-8, 1921.  
Type locality: "Morphy in der Sierra Nevada", Cal.  
Michaelsen's spelling of the type locality is rather cryptic. Perhaps he refers to Murphy's Cal. This is part of the *marmoratus* group according to Michaelsen, and it is likely that Eisen would have considered it another subspecies of *P. marmoratus* Eisen.

PLUTELLUS KINCAIDII Altman

- Plutellus kincaidii* Altman: Oligochaeta of Washington, U. of Wash. Pub. in Biol., vol. 4, no. 1, pp. 74-78, figs. 1-12, 1936.  
Type locality: Near the estuary of the Naselle R., Willapa Harbor, Wash.  
This species is also very near *P. marmoratus*. The affinities of this group must be investigated.

Examination of the types reveals that the clitellum extends from 13 to 18 inclusive in this species (thinner on 18). The original description is in error. Types are in the collection of the Zoology Department of the University of Washington.

PLUTELLUS TOUTELLUS Altman

- Plutellus toutellus* Altman: Oligochaeta of Washington, U. of Washington Pub. in Biol., vol. 4, no. 1, pp. 78-81, figs. 13-22, 1936.  
*Plutellus oregonensis* Smith: Proc. U. S. Nat. Mus., vol. 84, no. 3009, pp. 177-180, 1937.  
Type locality: A bar in the Toutle R., near Toledo, Wash.

Study of the description of *P. toutellus* Alt. reveals a serious discrepancy between the textual description of this species and Altman's figures of anatomical details. Although he states (p. 80) that in the type there is a "swollen ridge . . . that stretches in 8/9 from one spermathecal pore to the other", both his figured sagittal section and the ventral view of the entire worm show this ridge to be located on intersomite 9/10. Examination of the slides of the unique type of *Plutellus toutellus* reveals that this ridge is located on 9/10. Once this correction is made, this species is found to be identical

with *P. oregonensis* Smith. Since Altman's paper appeared in the year prior to Smith's, the name *P. oregonensis* Smith must be reduced to a synonym and this species becomes known as *P. toutellus* Alt. and the known range of *P. toutellus* Alt. is thereby extended to include that of *P. oregonensis* Smith. This species has not yet been collected by the authors in the kind of environment in which the type was found. It is characteristic of the deep soil of pastures and hedgerows in the Willamette Valley and the Douglas fir forests of the east side of the Coast Range in northwestern Oregon, and is the most abundant of the native worms in such locations.

The clitellum of the species is not thickened uniformly dorsally and ventrally, but is thinner ventrally, especially posterior to 16. The type is in the Zoology Department of the University of Washington.

***Plutellus toutellus swiftae* Smith n. comb.**

*Plutellus oregonensis swiftae* Smith: Proc. U. S. Nat. Mus., vol. 84, no. 3009, p. 180, 1937.

Type locality: Bottomlands of the Mary's R., Ore.

Since *P. oregonensis* Smith has been found to be synonymous with *P. toutellus* Alt., *P. oregonensis swiftae* Smith must be considered a subspecies of *P. toutellus* Alt. The types of this subspecies were collected along the "Mary's River in the Cascade Mountains" in Oregon according to Smith. The Mary's River, however, rises in the Coast Range west of Corvallis, Oregon. The authors have collected this subspecies near the Willamette River north of Salem, Oregon. The Mary's River is tributary to the Willamette.

***Plutellus altmani* nom. nov.**

*Plutellus decatheca* Altman: Oligochaeta cf Washington, U. of Wash. Pub. in Biol., vol. 4, no. 1, pp. 82-85, figs. 23-32, 1936.

Type locality: Near the estuary of the Naselle R., Willapa Harbor, Washington.

This name is preoccupied by *Plutellus decatheca* Michaelsen: Oligochäten aus verschiedenen Gebieten, Mitteilungen aus dem Naturhist. Mus. Hamburg, XXVII, pp. 81-83, figs. 14-16, 1910. *P. decatheca* Mich. is from Tasmania.

This species is renamed in honor of its describer, Luther C. Altman. The types are in the Zoology Department of the U. of Washington.

**PLUTELLUS GARLOUGHI Smith**

*Plutellus garloughi* Smith: Proc. U. S. Nat. Mus., vol. 84, no. 3009, pp. 175-177, 1937.

Type locality: Multnomah, Ore.

**Genus MEGASCOLIDES McCoy**

*Megascolides* McCoy: Prodrum of the Zoology of Victoria, vol. 1, decade 1, p. 21, 1878.

**MEGASCOLIDES AMERICANUS Smith**

*Megascolides americanus* Smith: Amer. Nat., vol. 31, p. 203, 1897.

*Notoscolex americanus* (Frank Sm.): Michaelsen, Oligochaeta, Das Tierreich, 10 Lief., XXIX plus 575 pp., p. 188, Berlin, 1900.

*Megascolides americanus* Smith: Altman, Oligochaeta of Washington, U. of Wash. Pub. in Biol., vol. 4, no. 1, pp. 86-88, figs. 33-41, 1936.

*Megascolides americanus* Smith: Proc. U. S. Nat. Mus., vol. 84, no. 3009, p. 161, 1937.

Type locality: Pullman, Washington.

Both Altman (1936) and Smith (1937) add significant details to the description of *M. americanus* Smith.

**MEGASCOLIDES WELLSI Altman**

*Megascolides wellsi* Altman: Oligochaeta of Washington, U. of Wash. Pub. in Biol., vol. 4, no. 1, pp. 89-92, figs. 42-52, 1936.

*Megascolides macelfreshi* Smith: Proc. U. S. Nat. Mus., vol. 84, no. 3009, pp. 166-168, 1937.

Type locality: Monroe, Ore.

Additional localities: Willamette Valley—Salem, Dayton, and McMinnville, Oregon; Coast Range—Boyer, Lincoln County, Ore.

Analysis of the descriptions of *M. wellsi* Alt. and *M. macelfreshi* Smith in an attempt to determine whether they might be synonymous revealed close agreement with a very few discrepancies. Since specimens in the hands of the authors, one of which had been determined as *M. wellsi* by Altman, agreed perfectly with the description of *M. macelfreshi*, the types of *M. wellsi* were examined and were found also to agree with the description of *M. macelfreshi*. Although the description of *M. wellsi* states that it is "purely micronephridial" none of the posterior ends of the 11 types were found to have been dissected. Dissection of the posterior end of one of the types revealed several micro- and one pair of meganephridia in each of the posterior segments, agreeing with specimens previously determined as *M. macelfreshi* by the authors, as well as with Smith's description. Approximately 40 of the posterior segments contain meganephridia in this species. The funnels are large and there is no expanded terminal portion. An additional important difference in the two descriptions lies in the statement that *M. wellsi* has sperm sacs in 10, 11, and 12. No sperm sacs were found in somite 10 in the two types examined, thus agreeing with *M. macelfreshi*. The three specimens from northwestern Oregon in the collection of the authors also lack sperm sacs in 10.

Descriptions of the two species agree in all other important points necessitating the conclusion that the names are synonyms. Since Altman's paper appeared in 1936, and Smith's in 1937, this species must be known as *Megascolides wellsi* Altman. The types are in the Zoology Department of the U. of Washington.

#### MEGASCOLIDES CASCADENSIS Smith

*Megascolides cascadenis* Smith: Proc. U. S. Nat. Mus., vol. 84, no. 3009, pp. 164-166, 1937.

Type locality: "Cascade Range," Oregon.

This species, represented only by the unique type, is closely related to *M. wellsi* Alt. However, the close agreement of all specimens of *M. wellsi* with each other serves to emphasize its probable distinctness.

#### MEGASCOLIDES MICHAELSENI Smith

*Megascolides michaelseni* Smith: Proc. U. S. Nat. Mus., vol. 84, no. 3009, pp. 168-171, 1937.

Type locality: Netarts, Oregon.

#### MEGASCOLIDES EISENI Smith

*Megascolides eiseni* Smith: Proc. U. S. Nat. Mus., vol. 84, no. 3009, pp. 171-174, 1937.

Type locality: Multnomah, Oregon.

As is apparent from even a casual inspection of the foregoing list, the nomenclature of these two genera in North America is already complex. It cannot be too strongly emphasized that an adequate classification of this group is not simply attained. Like many other zoological groups these worms appear to be in a state of flux, many related yet variable populations being found as investigations are extended to cover more of the great variety of ecological communities that occur in the Pacific States.

Critical distributional studies are need to determine, if possible, whether we have here many different worms which can be given the rank of species, or whether we are concerned with a few species which are sending out branches in several directions. The specific interrelationships are undoubtedly intricate, especially in *Plutellus*. The authors hope that their studies, current and future, may help materially in resolving these problems.



## Gill Parasites from Louisiana Fishes with a Description of *Urocleidus wadei* n. sp.\*

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A survey of the literature reveals only two papers concerning the Monogenea from fishes in Louisiana. Summers (1937) described *Anchoradiscus triangularis* from the "small sunfish" *Lepomis symmetricus* Forbes, and Summers and Bennett (1938) presented a brief survey of gill flukes from fishes collected near Baton Rouge and New Roads, Louisiana. The present paper presents the description of a new species, *Urocleidus wadei* from the flier sunfish *Centrarchus macropterus* (Lacépède) and a number of new host and distribution records. The new species is the first to be reported from the flier sunfish and is the only one recorded for this host.

### UROCLEIDUS WADEI n. sp.

*Host and locality.*—*Centrarchus macropterus*, Tremont, La.

*Site of infestation.*—Gills.

*Specimens studied.*—Eleven.

*Type specimens.*—Cotypes, University of Notre Dame type collection. Notre Dame, Indiana.

*Description.*—Relatively small tetraonchinae, length 0.227 mm (0.198–0.324 mm), greatest body width 0.133 mm (0.110–0.156 mm). Eyespots four in number, members of posterior pair larger than those of anterior; few melanistic granules distributed over head region. Cephalic lobes moderately developed. Vitellaria well developed and occurring in lateral bands which are confluent anteriorly behind the eye spots and posteriorly in front of the haptor. Pharynx indistinct, obscured by vitellaria. Peduncle indistinct in most specimens; haptor generally subhexagonal in shape, greatest width about 0.083 mm (0.077–0.090 mm), length 0.046 mm (0.039–0.052 mm). Hooks fourteen in number with characteristic arrangement for the genus, and each composed of a base, a solid shaft, a sickle-shaped termination, and an opposable piece. Hooks of pair number five somewhat smaller than others, about 0.012 to 0.014 mm long, with a solid elongate ovate base and with a slender posteriorly projecting structure arising from the sickle-shaped termination. Each of the remaining hooks 0.018 to 0.020 mm in length, with a solid elongate ovate base, and with a poorly developed posteriorly projecting structure arising from the sickle-shaped termination. Anchors slightly dissimilar in size; bases bifurcate with superficial roots longer than deep roots; shafts solid, usually with well developed wings and with a spur-shaped projection arising immediately above the internal angle formed by the junction of the shaft and points. Anchor points solid, elongate, and attenuate. Dorsal anchor 0.032 mm (0.030–0.035 mm) long; greatest width of base 0.010 mm (0.009–0.011 mm).

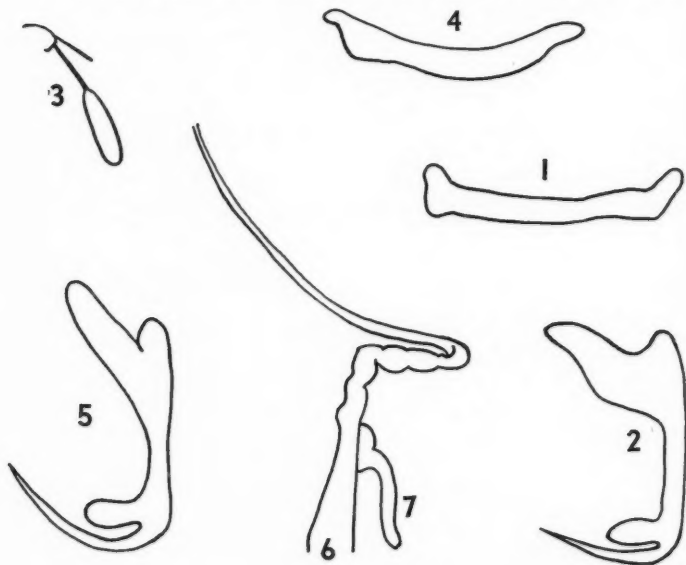
\* A contribution from the Department of Biology, University of Notre Dame, Notre Dame, Indiana, and Corpus Christi Junior College, Corpus Christi, Texas.

Ventral anchors 0.035 mm (0.034–0.038 mm) long and 0.010 mm (0.009–0.011 mm) in greatest base width. Bars similar in size and shape, bent slightly in middle and with enlarged ends. Bars narrow and about 0.027 to 0.032 mm long (Fig. 4). Cirrus a long tube often lying in broad coils or folds (Fig. 6); length 0.062 mm (0.054–0.077 mm). Proximal portion easily visible because of a broader, heavier construction; distal portion of cirrus thin and often obscured by the vitellaria. A cirral thread was observed in two of the specimens. Accessory piece small, solid, bifurcate terminally, and non-articulate with base of cirrus (Fig. 7); accessory piece not observed in all specimens. Vagina not observed.

*Urocleidus wadei* resembles those species of *Urocleidus* that possess spurs on the anchor shafts. It most closely resembles *Urocleidus acer* (Mueller, 1936) but differs from it by having a smaller body size, smaller anchors, and a longer, broadly coiled cirrus.

Two hosts, *C. macropterus* were seined from a swamp pool on the Wade farm approximately two miles north of Tremont, Louisiana. The gills were removed and preserved in ten percent formalin and the parasites later were removed and mounted in a glycerin-gelatin medium according to the method used by Mizelle and Seamster (1939).

The author wishes to acknowledge the aid given by Mr. James Wade of



Figs. 1-7. *Urocleidus wadei* n. sp. 1. Dorsal bar, 2. Dorsal anchor, 3. Hook (typical), 4. Ventral bar, 5. Ventral anchor, 6. Cirrus, 7. Accessory piece.

All figures were drawn at the same magnification with the aid of a camera lucida.

West Monroe, Louisiana in collecting the host specimens used in this study and the helpful suggestions offered by Dr. John D. Mizelle of the University of Notre Dame.

#### HOST AND DISTRIBUTION RECORDS

Summers and Bennett (1938) recorded seventeen species of gill flukes (12 known and 5 unidentified) from seven species of fish taken near Baton Rouge and New Roads, Louisiana. The hosts in the present work were seined in the fall of 1944 from swamp pools and bayous near Monroe and Tremont, Louisiana in the north central part of the state. Ten species of fish were examined and a total of eleven species of gill parasites recovered.

*Urocleidus seculus* is reported for the first time since its original description from California by Mizelle and Arcadi (1945).

The following is a list of gill parasites reported from Louisiana fishes. New distribution records are indicated by an asterisk; new host records by two asterisks.

Host and Parasite	Louisiana Localities	Reported by
<i>Lepomis macrochirus</i> Rafinesque		
* <i>Urocleidus acer</i> (Mueller, 1936) .....	Tremont	Present author
<i>Urocleidus ferox</i> .....	Baton Rouge,	
Mueller, 1934 .....	New Roads	Summers & Bennett 1938
<i>Urocleidus</i> sp. ....	Baton Rouge	Summers & Bennett 1938
<i>Cleidodiscus nematocirrus</i>		
Mueller, 1937 .....	Baton Rouge	Summers & Bennett 1938
<i>Actinocleidus longus</i>		
Mizelle, 1938 .....	Baton Rouge	Summers & Bennett 1938
<i>Actinocleidus oculatus</i>		
(Mueller, 1934) .....	Baton Rouge	Summers & Bennett 1938
<i>Actinocleidus incisor</i>	Baton Rouge,	
(Mizelle, 1936) .....	New Roads	Summers & Bennett 1938
<i>Lepomis megalotis</i> Rafinesque		
* <i>Urocleidus acuminatus</i>		
(Mizelle, 1936) .....	Tremont	Present author
<i>Urocleidus</i> sp. ....	Tremont	Present author
<i>Cleidodiscus nematocirrus</i>		
Mueller, 1937 .....	Tremont	Present author
<i>Actinocleidus</i> sp. ....	Tremont	Present author
<i>Ambloplites rupestris</i> (Rafinesque)		
<i>Urocleidus</i> sp. ....	Baton Rouge	Summers & Bennett 1938
<i>Urocleidus</i> sp. ....	Baton Rouge	Summers & Bennett 1938
<i>Huro salmoides</i> Lacépède		
<i>Urocleidus principalis</i>		
(Mizelle, 1936) .....	Baton Rouge	Summers & Bennett 1938
<i>Urocleidus furcatus</i>		
(Mueller, 1937) .....	Baton Rouge	Summers & Bennett 1938
<i>Actinocleidus fusiformis</i>		
(Mueller, 1934) .....	Baton Rouge	Summers & Bennett 1938
<i>Actinocleidus</i> sp. ....	Baton Rouge	Summers & Bennett 1938

Host and Parasite	Louisiana Localities	Reported by
<i>Ameiurus melas</i> (Rafinesque)		
<i>Cleidodiscus pricei</i>		
Mueller, 1936 .....	Baton Rouge	Summers & Bennett 1938
	Tremont	Present author
<i>Cleidodiscus</i> sp. ....	Baton Rouge	Summers & Bennett 1938
<i>Gambusia affinis affinis</i>		
(Baird & Girard)		
* <i>Urocleidus seculus</i>		
Mizelle & Arcadi, 1945 .....	Tremont	Present author
<i>Fundulus dispar</i> (Agassiz)		
<i>Urocleidus umbraensis</i>		
Mizelle, 1938 .....	Baton Rouge	Summers & Bennett 1938
<i>Pomoxis annularis</i> Rafinesque		
<i>Cleidodiscus vancei</i>	Baton Rouge,	
Mizelle, 1936 .....	New Roads	Summers & Bennett 1938
<i>Pomoxis nigro-maculatus</i> Lacépède		
* <i>Cleidodiscus capax</i>		
Mizelle, 1936 .....	Monroe	Present author
<i>Lepomis symmetricus</i> Forbes		
<i>Anchoradiscus triangularis</i>		
(Summers, 1937) .....	Baton Rouge	Summers & Bennett 1938
<i>Centrarchus macropterus</i> (Lacépède)		
** <i>Urocleidus wadei</i> n. sp. ....	Tremont	Present author
<i>Aphredoderus sayanus</i> (Gilliams)		
** <i>Dactylogyrus aureus</i>		
Seamster (in press) .....	Tremont	Present author

The following hosts were examined but no gill parasites were recovered from them.

<i>Notemigonus crysoleucas</i>	
<i>aureus</i> (Mitchell) .....	Monroe
<i>Dorosoma cepedianum</i>	
(LeSueur) .....	Monroe
<i>Esox niger</i> LeSueur .....	Tremont

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## Morphology of Globivalvulina

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The earliest record of any foraminifer referable to the generic group now known as *Globivalvulina* Schubert is Brady's *Valvulina bulloides*<sup>1</sup> figured from Upper Carboniferous strata in Iowa and Belgium and recorded also from Russia. In 1920, Schubert proposed the name *Globivalvulina* for the "globigerina-like" Paleozoic forms and designated *Valvulina bulloides* Brady, 1876, as the genotype species. Presumably because Brady had presented a sufficiently detailed analysis of the morphology of the species, Schubert did not take the trouble to describe his new genus further than to offer a casual statement<sup>2</sup> on the character of the shell material.

Brady's study of *Valvulina bulloides* was based primarily on specimens found in material from southwestern Iowa (labeled "residue from clayey partings of layers of *Fusulina* limestone. Upper Coal Measures.") sent to him by C. A. White, then State Geologist of Iowa. The Belgian material was a later acquisition to his collection, and in this he found small specimens that were conspecific with his already named and described species from Iowa. The Iowa exposure that yielded the figured test should therefore be regarded as the type locality for the species, but unfortunately it is doubtful whether the exact geographic position of this exposure can ever be ascertained, though considerable geologic literature by White, Meek, and other contemporary field geologists working in the central states has been searched for some clue. It is necessary, therefore, to rely upon abundant available material collected in recent years from other Midcontinent Pennsylvanian and Permian strata. Samples contributed by Dr. Lewis Cline from three outcrops in Iowa have failed to yield globivalvuline tests; several samples from many stratigraphic positions in the Texas upper Paleozoic section have yielded hundreds of tests in divers conditions of preservation.

It is clear from Brady's discussion that his specimens were mineralized, probably to the light-absorbing crystalline calcite, and that they bore adherent granules of extraneous material. Consequently salient morphologic details of *Valvulina bulloides* were obscured (as he admits) by poor preservation. The last two or three inflated chambers separated by deeply incised sutures suggested so strongly a resemblance to globigerine tests, that, without sharp definition of the earlier small chambers in the succession as a clue, the assumption of a

<sup>1</sup> Brady, H. B., A monograph of Carboniferous and Permian Foraminifera (the genus *Fusulina* excepted): Palaeontogr. Soc., Mon. 30, p. 89, pl. 4, figs. 12-15, 1876. Under *Valvulina* this author included also forms now referable to *Tetralaxis* (possibly also *Polytaxis*), *Valvulina*, and *Ruditaxis*.

<sup>2</sup> Very free translation: Where Paleozoic representatives of globigerina-like forms are known, as in the Carboniferous of North America, England, Russia, Australia, etc., as the case may be, they are not globigerinas but rather "*Valvulina*" *bulloides*, for which I propose the name *Globivalvulina*, forms with sandy, agglutinate, partly perforate shell. (Pal. Zeitschr., vol. 3, p. 153, 1920).

rotaliform disposition of the chambers in the test was readily made, and their arrangement was described as "obscurely spiral". Perhaps foreign calcitic matter deposited on some specimens was interpreted as true chambers, since the figured test from Belgium is obviously incorrectly drawn, as Cushman and Waters have already stated,<sup>3</sup> with the added correction, "the spire is not in the center but low at one side". Had Brady been able to obtain enough reflection of light to emphasize the delicate relief of two or three more chambers back toward the initial extremity, he would no doubt have realized that at least the latter stage in the chamber sequence was biserial, which is clear in his thin sections. As is common where calcitized tests of *Globivalvulina* occur, the series of early small chambers, which are strongly curved over one side of the compact test, appears as a fairly smooth lobe, and this feature was figured by Brady as a globular chamber (Brady's fig. 12c), more recently regarded as the "spire . . . low at one side". Several subsequent authors have dealt with similarly obscure material, and the original error of the rotaliform arrangement of the chambers in the test of *Globivalvulina* has persisted, so that the family Trochamminidae has seemed its logical taxonomic position.

The varying conditions of preservation of tests of *Globivalvulina bulloides* (H. B. Brady) in the many samples of unconsolidated calcareous shales and marls collected in the Texas Pennsylvanian and Permian geologic section have not only introduced Brady's difficulties in interpreting the morphology of this species from comparatively few calcitized specimens in some places, but have also made possible observations of all chambers in the sequence from the proloculum to maturity in specimens carrying the dense, light-reflecting shell material. Even where specimens are composed wholly of crystalline grey calcite, so that it is common to find only the last two or three chambers distinctly differentiated by incised sutural depressions, large suites of such tests in the Texas strata are likely to include at least a few that carry faint ferruginous stains or dark internal chambers fillings, which help to define the entire succession of individual chambers. In some marls specimens are excellently preserved with their dense, fibrous and granular shells, which reflect the light well and reveal clearly the slight sutural depressions between chambers of the initial extremity. Observations on hundreds of specimens of *Globivalvulina* indicate the consistency of the compact biserial arrangement of closely interlocking chambers throughout the growth of the test of all species and along an open helicoid axis (fig. 1b), similar to the general plan of *Ehrenbergina*, except that in none of the species of *Globivalvulina* now known is the earliest extremity of the coil involute, that is, the proloculum remains exposed at the end of the sharply curled initial extremity of the axis of biseriality and in mature tests is visible in the ventral aspect of the test.

The biserial arrangement of the successive later chambers in *Globivalvulina* is more sharply defined in some species than in others, a difference dependent primarily upon the position of the plane of biseriality. As a specimen of *G. biserialis* Cushman and Waters<sup>4</sup> lies on its ventral face and is viewed from

<sup>3</sup> Cushman, J. A. and Waters, J. A., The Foraminifera of the Cisco group of Texas: Texas Bull. 3019, p. 72, 1930.

<sup>4</sup> Cushman, J. A. and Waters, J. A., Additional Cisco Foraminifera from Texas: Cushman Lab. Foram. Res., vol. 4, p. 64, pl. 8, fig. 7, 1928.

the highly convex dorsal side, the alternate and deeply interlocking semilunate later chambers display very sharply the biserial relationship of the several mature chambers, and the axis of biseriality is projected on the plane of vision as a central straight line (figs. 1a, 2a), because in this species the plane of biseriality is normal to the plane of the ventral face and to the parallel plane of vision for the dorsal view. When *G. bulloides* (H. B. Brady), however, lies in the same position for observation, its more globular and less deeply interlocking mature chambers are less obviously biserial, because its plane of biseriality lies at an acute angle to the plane of the ventral face of the test, and consequently the axis of biseriality over the highly arched surface of the dorsal side is projected on the plane of vision for the dorsal view as a broadly curved line to one side of center, thus tipping out of direct view the symmetry of the test (figs. 4a, 5b). The true relationship of the successive mature chambers can be made sharply apparent only by lifting the test laterally to such a position that the plane of biseriality of the chambers of the test is normal to the plane of vision, on which the projection of the axis then becomes a central straight line.

The ventral view of especially well-preserved globivalvuline tests bearing the dense, uncalcitized shell shows not only the septal faces of the embracing final pair of chambers but also the proloculum and the dorsal aspect of the several succeeding early small chambers, which are arranged biserially along the axis that curves strongly over one side of the mature tests (figs. 3, 4b, 5c). Almost every locality where tests of species of *Globivalvulina* are fairly fre-

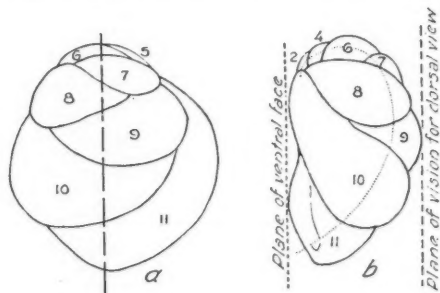
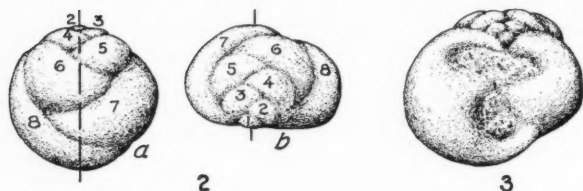


Fig. 1. *Globivalvulina biserialis* Cushman and Waters, x50, from Millsap Lake formation, Grindstone Creek member, about 0.1 mile south of Goen Cemetery, close to the east edge of Palo Pinto County, about  $5\frac{1}{2}$  miles southwest of Millsap, Texas (Bur. Econ. Geol., Univ. Texas, Loc. 181-T-5). This is an exceptionally large test found in material where the species is unusually well developed. a, Dorsal view showing typical semilunate and deeply interlocking chambers along the helicoid axis of biseriality, which in this species lies in a plane normal to the plane of the ventral face of the test (on which the specimen rests) and is therefore projected on the parallel plane of vision for this view as a straight line. b, Side view in which the plane of the ventral face of the test and the plane of vision for the dorsal view are parallel lines and the plane of biseriality carrying the helicoid axis of biseriality (dotted line) lies parallel to the plane of vision for this view. The proloculum is just out of sight and behind the anterior lateral extremity of chamber 10.

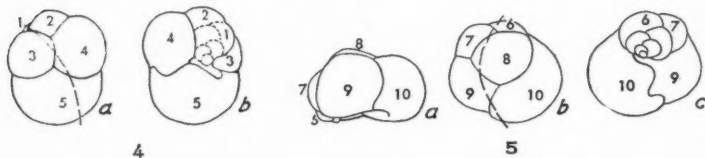




Figs. 2, 3. *Globivalvulina biserialis* Cushman and Waters, x60, from Graham formation, just below Gunsight limestone ledge, west bank of Salt Creek, 1 mile west of Graham, Young County, Texas (Bur. Econ. Geol., Univ. Texas, Loc. 251-T-3).

2. Test of moderate and average size. *a*, Dorsal view, as the test lies on its ventral face, showing the deeply interlocking semilunate late chambers arranged biserially along the helicoid axis that defines a plane normal to the plane of the ventral face and to this plane of vision, on which the axis is projected as a straight line (broken vertical line). *b*, Same test viewed from its initial extremity showing biserial arrangement throughout its ontogeny.

3. Ventral view of a more mature specimen showing the dorsal aspect of the initial extremity of the chamber succession curved over one side of the test. The umbilical area is partially filled with rough mineral matter, so that the outline of the valvular projections along the inner margins of the last two chambers is not the true outline, though it shows the general relationships correctly.



Figs. 4, 5. *Globivalvulina bulloides* (H. B. Brady), x50, from Pueblo formation (Permian), Camp Creek member, north end of high elevation west of Saddle Creek about 1 mile south of its mouth, McCulloch County, Texas (Bur. Econ. Geology, Univ. Texas, Loc. 153-T-123).

4. This specimen probably represents fairly well the type of material with which Brady worked in describing this species. *a*, Dorsal view of the test lying on its ventral face and showing the typical shallow interlocking of the globose chambers along the axis of biseriality (broken line), which in this species always describes a broad curve on this plane of vision (parallel to the plane of the ventral face), since the plane of biseriality lies at an acute angle to the plane of the ventral face. *b*, Ventral view of same specimen with outlines of the distinctly differentiated chambers in full lines. Absorption of light in the tumid area of the earliest chambers allows no visual differentiation into separate chambers with sufficient lucidity to reveal the true chamber arrangement, but accompanying tests in better state of preservation have indicated the approximate arrangement (dashed-line outlines) in the round initial extremity of the test.

5. Well-preserved test, which exhibits clearly all individual chambers in the sequence. *a*, Side view showing thickness of the test. *b*, Dorsal view showing typical broad and shallowly interlocking chambers along the curved axis of biseriality that defines a plane lying at an acute angle to the plane of the ventral face on which the specimen lies. *c*, Ventral view showing large final valvular extension of the inner edge of the septal face.

quent has furnished enough such revealing tests to prove the consistency of the biserial arrangement throughout ontogenetic development.

Some descriptions have pointed to inclusions of mineral grains within the shell masonry at some places where species of this genus have been found, implying that the shell is inherently adventitious or agglutinate. In all the material studied no evidence of extraneous matter built into the shell material itself has been found. Wherever the surfaces of the tests carry mineral grains, these grains are wholly superficial and have been acquired from the matrix through subsequent accretion in the mineralizing processes in the strata, since ostracodes, bryozoans, and other accompanying shell surfaces are all similarly characterized. Whether the shell was originally porous is left for student with the requisite high-power petrographic equipment to ascertain. In globivalvuline shells in the Midcontinent area, so far as available collections are concerned, any original perforations have been filled by infiltrated calcite, though a few exceptional specimens show some faint and evenly distributed minute depressions that are suggestive of an original perforate character, as have also a few tests of *Endothyra* and *Polytaxis*.

On the basis of this study, the following emended definition of *Globivalvulina* is offered.

The hemispherical to subglobular, calcareous, very finely fibrous or granular, smooth test comprises a compact biserial succession of numerous, rapidly enlarging chambers arranged in a planispiral coil along an axis of biseriality that describes an open helioid curve. The strongly convex dorsal side of the test exhibits all the chambers of the test and follows the outer side of the curved axis of the biserial chambers. The concave ventral side of the test shows the ventral faces of only the final pair of chambers, which ventrally are wholly embracing; this aspect shows also the proloculum and the dorsal side of the sharply coiled early pairs of chambers, which curl over one side of the compact hemispherical test between the lateral extremities of the late chambers. The periphery of the test consists largely of the lateral edges or flanks of the last pair of chambers and may be broadly rounded (as in *G. bulloides*) or narrowly rounded (as in *G. biserialis*). About centrally located along the inner edge of the septal face is usually a more or less well developed valvular projection into the umbilical depression, and under this valve lies the low slit-like opening that comprises the aperture of the test. Generally the final valvular projection overlaps that of the penultimate chamber, so that only a single aperture exists at one time, but rarely this overlap is incomplete, so that possibly both apertures functioned at the same time.

Because *Globivalvulina* consists of a biserial arrangement of chambers in a planispiral coil, the genus is herewith placed in the family Cassidulinidae, even though the aperture of this Paleozoic form is not harmonious with those in the rest of the family. So much geologic section between the top of the Paleozoic system and the Cretaceous remains to be investigated for its foraminiferal content, that no comment on the true phylogenetic relationships of *Globivalvulina* is now justified. Some gradual evolution in the aperture during this long interval in history may someday confirm this classificatory position or may indicate some other position that is more natural. However, it is unlikely that a classification based on phylogeny (necessarily three-dimensional and reticulate) can ever be made compatible with the more practical 2-dimensional and linear classification. This family position for *Globivalvulina* follows the plan of a practical grouping of genera based primarily on geometrical relationships of successive chambers in the secreted, calcareous foraminiferal shell.

## Application of Statistical Methods to the Analysis of Ecologic Association Between Species of Birds

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Very considerable advances have been made in recent years in the development of biometric methods suitable for the analysis of ecologic relations in nature. Ornithologists, however, have been rather slow to apply these new mathematical technics to the solution of their problems. There is here presented a description of the manner in which biometric technics assisted in the analysis of one particular phase of bird behavior.

The particular study here described resulted from an impression gained by my wife and myself that birds of several kinds tended to visit our yard and feeding-shelf at approximately the same time, there forming aggregations of mixed species. It was noted that two species would seldom actually feed on the window-shelf together, but that several species might be present in the yard at the same time. Individuals of different species sometimes came in irregular alternation to the feeding-shelf. On the afternoon of December 24, 1946, in particular, we noted in the yard an exceptional concentration of species, consisting of cardinals, chickadees, tufted titmice, English sparrows, ring-necked pheasants, a downy woodpecker, and a brown creeper. Even a fox squirrel joined the aggregation.

In order to test the hypothesis that these species of birds, or some of them at least, were tending to aggregate in flocks of mixed species, it was necessary to secure a quantitative measure of their association with one another. Otherwise there was the possibility that each species actually moved about independently, but that the human observer best remembered those rare occasions when several species happened to be present in the yard at the same time.

Counts at fifteen-minute intervals during each of four days were accordingly made of the number of individuals of each species of bird present on a selected census area. The census area was a portion of our yard at 2022 Day Street, Ann Arbor, Michigan. The dimensions of the area selected are approximately fifty by fifty feet. A portion of our house extends along most of the northern boundary. A feeding shelf, provided with suet, cracked corn and other grains, and sunflower seeds, projects out from a second-story window. Along the eastern border of the census area there is a thick line of shrubs and a large cherry tree. Many birds roosted for a time in these shrubs and tree or fed on the ground beneath, where seeds also were scattered. A large pear tree near the middle of the plot attracted a few birds from time to time. Between these trees and the house is a rock garden on which some birds also occasionally fed. The rest of the plot is relatively open and few birds were ever seen there.

The counts were made from dawn to dusk on December 25, 1946 and on

January 12, 19, and 26, 1947. The time from the beginning of one count to the next count was fifteen minutes. The actual counting usually occupied only a minute or two, but sometimes took as much as five minutes. The attempt was made to record only those birds which were actually present on the plot simultaneously. In a few instances the interval between the beginning of two successive counts were longer than fifteen minutes, but not more than thirty minutes, and in a very few instances the interval between counts was a little less than fifteen minutes.

To assist in identifying the species a pair of low-power field glasses were used. Two birds passed through the area so hurriedly that they could not be identified. These two unidentified birds were omitted from the counts.

The weather on the census days varied from clear to cloudy, sometimes with snow flurries. The temperature ranged from 16° to 51° F. The ground was partly covered by snow on two of the days and nearly bare on the other two.

All the species of birds recorded in any numbers in the census showed at this winter season some tendency to occur in flocks. Too few observations were obtained of the junco and of the ring-necked pheasant to measure the size of their flocks with any accuracy. The flocks of the cardinal averaged 2.04 (maximum 5) and of the chickadee 1.80 (maximum 3) individuals. Both these species were observed to travel in small, loose flocks. The English sparrow travelled in larger, more compact bands, containing on our area an average of 4.98 individuals, but sometimes numbering fifteen or more.

One objection that can be made to the methods employed for gathering the data is that the fifteen-minute interval between the counts was rather brief. Often a bird or a flock of a particular species remained on the area over two or more periods. Actually then each period of observation was not taken wholly at random, but was related in some degree to the periods immediately preceding and following it. This influence on one another of periods adjacent in time reduces by an unknown amount the efficiencies of these observations for statistical treatment. A more random set of observations would have been obtained by spacing the periods at longer intervals, but then some visitors to the area might have been missed.

If the occurrence of the several species on the area is at random, then the number of census periods when no species, one species, two species, and so on, should occur, will form a Poisson series. The total number of census periods in the four days of observation was 131 and the mean number of species present per period was 0.664. In Table 1 is given the expected Poisson series for these data. For calculating the Poisson series for this particular mean and given number of observations, help was obtained from Snedecor (1946: 442).

It will be noted from the table that there are small deviations from the numbers of species expected to occur together according to a Poisson distribution. In order to measure the significance of these deviations the chi-square of each deviation has been calculated. The sum of the chi-squares is only 1.779, which is statistically insignificant (Snedecor, 1946, table 9.2). Inasmuch, then, as the association of the species in such groups as occurred on the

TABLE 1.—Number of species present in same period on area of observation

No. of species present in same period	Frequency of occurrence —— periods	Expected frequency in Poisson distribution	Deviation from expected	(Deviation) <sup>2</sup> —— expected
0	65	67.36	-2.36	.083
1	49	44.73	+4.27	.408
2	12	14.85	-2.85	.547
3	4	3.29	+.71	.153
4	1	.55	+.45	.368
5 and up	0	.22	-.22	.220
Total	131	131.00		1.779

Mean species per period = 0.664

Chi-square = 1.779; degrees of freedom = 6 - 2 = 4

census area could have been due to chance alone, the original impression that the several species tended to form aggregations of mixed species is not confirmed by these observations.

Although the occurrence of the several species of birds on the census area thus is shown to be generally at random, the statistical method above employed is too rough to show whether or not any particular pair of the species might tend to be associated. For such a measure of association we may use the method illustrated in Table 2, where the possible association between the cardinal and the chickadee is tested (see Dice, 1945). Biometricians would usually use a simpler formula for calculating the significance of this association. The method here employed, however, is easy to follow.

The data presented in Table 2 indicate that there is a tendency for chickadees and cardinals to be associated under the conditions of the observations. The two species occurred together on the census area on eight observation periods, while on the basis of chance they should have been associated only during 3.21 periods. The deviation from expectation is highly significant statistically, for the chi-square, with one degree of freedom, is 10.280.

TABLE 2.—Ecologic association between cardinals and chickadees

Based on observations taken at 15-minute intervals on 4 winter days at Ann Arbor, Mich.

	Periods observed	Expected	Deviation	(Deviation) <sup>2</sup> —— expected
Cardinal only .....	20	24.79	-4.79	0.926
Both species .....	8	3.21	+4.79	7.156
Chickadee only .....	7	11.79	-4.79	1.946
Neither species .....	96	91.21	+4.79	0.252
Totals	131	131.00		10.280

Association index, cardinal/chickadee = .56; chickadee/cardinal = .29

Chi-square = 10.280\*; degree of freedom = 1

Similar calculations were made of the tendency for cardinals to be associated with English sparrows and for English sparrows to associate with chickadees. Both these other associations proved to be entirely at random, for the conditions of the observations. The number of associations between species other than cardinals, chickadees, and English sparrows was too few to justify statistical treatment.

Cardinals and chickadees have such different habits and eat such different foods that there seems no good reason why these two species should tend to associate with one another. Could it be that their indicated association is an artifact of our method of study? We should certainly never blindly accept as true any such statistical indication. It has already been pointed out that the successive 15-minute periods of observations are related to one another in a somewhat non-random manner, and that this reduces the efficiency of the observations for statistical use.

A calculation of the length of stay of each species of bird on the census area shows that the cardinal averaged 1.87 consecutive 15-minute periods and that the maximum number of consecutive periods for this species was eight. The average stay of the chickadee on the area was 1.67 periods, with a maximum of four consecutive periods. It is possible, however, that different individuals were represented on the census area in some consecutive periods, for only the presence of each species was recorded.

That the indicated association between chickadees and cardinals could have arisen by flocks of the two species remaining there together over several consecutive periods is shown by an inspection of the original records. On the morning of December 25 both species were associated for one period only. In the afternoon of that day, however, cardinals and chickadees were associated on the area in varying numbers on three consecutive periods. Likewise, on January 12 one cardinal and two chickadees were recorded together on the plot for four consecutive periods. These records constitute eight of the fifteen times the chickadee was recorded on the area during the four days of observation.

The cardinals and chickadees both came habitually to the feeding shelf, the cardinals for seeds and the chickadees mostly for suet. Very rarely did a chickadee dare come to the shelf when a cardinal was feeding there. The two species therefore tended to alternate at the shelf, with the chickadees waiting in the cherry or pear tree while a cardinal was feeding on the shelf. This habit tended to prolong the stay of the chickadees on the plot when cardinals also were present. The tendency for the occurrence of the chickadee to be more dependent upon the presence of the cardinal than the converse is shown by the association index (Dice, 1945) of the chickadee with the cardinal (cardinal/chickadee) being 0.56, while that of the cardinal with the chickadee (chickadee/cardinal) is only 0.29. It is probable, therefore, that the indicated association between chickadees and cardinals is spurious and is produced by a prolongation of the stay of chickadees on the area when cardinals are feeding at the shelf.

It is my recommendation that in any future studies of association between bird species the observations on any small area, such as this, should not be

repeated more frequently than once per hour. Such a longer interval between successive observations would make it unlikely that the length of stay of each species on the area might seriously affect the value of the records for biometrical computations.

At no time during the four days of intensive observation were more than four species of birds present on the census area at one time. The occurrence of the several species on the area has been shown above to be consistent with a wholly random association. Only the chickadee and the cardinal showed any tendency to occur on the area at the same time and this has been shown to be probably a spurious association, not based on any attraction between the two species. At no time was any tendency noted for the several species of birds to associate together in anything that could be called a mixed flock. The aggregations of species of birds sometimes noted on the census area must therefore be presumed to have assembled almost entirely as the result of chance.

The conclusion, however, should not be drawn that these or other species of birds may not be associated in mixed assemblages at other seasons or in other situations. In order to reach any valid general conclusions about the tendencies of the various species of birds to form ecologic aggregations we shall need many more quantitative studies.

#### SUMMARY

A statistical study, based on observation periods spaced fifteen minutes apart and covering four full days during December and January, indicates that the aggregations composed of several species of birds which sometimes occur in a yard in Ann Arbor, Michigan, are formed only by random association. When cardinals were on the feeding shelf, however, the chickadees waiting their turn at the shelf often remained on the area more than a random number of periods and thereby a spurious association with the cardinals was produced. Periods of observation of the birds on a small area should be spaced more than fifteen minutes apart if the data are to be treated statistically for measurement of the ecologic association between species.

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## The Pelt-Primeness Method of Aging Muskrats

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One of the primary factors determining the breeding potential of any game population is the sex and age composition. The importance of this receives emphasis when disparities become pronounced (Leopold, 1933). A rapid and efficient means of determining the age of muskrats is greatly needed as a management tool, for as Lay (1945) has pointed out the age ratio in muskrats is an important index to trapping pressure and marsh productivity. He believes that an abnormally high proportion of adults indicates poor breeding during the preceding season, while a high proportion of sub-adults indicates over-trapping. Certainly an abnormal age ratio indicates that the population is in critical condition and suggests that the open season may need modification.

During the past decade, several investigators have developed age criteria for muskrats, all of which have certain advantages as well as distinct disadvantages. Errington's (1939) method, based upon examination of the reproductive tract, has been used by Baumgartner and Bellrose (1943), and McCann (1944). Frequently, however, the field worker does not have access to carcasses and thus is unable to obtain age data by this method. Baumgartner and Bellrose's (*loc. cit.*) method is based upon the appearance of the external genitalia. This requires that the investigator gather his data from dead animals before skinning and, although more rapid than Errington's method, it is still too laborious and time-consuming, because the investigator must locate the trapper before his catch has been pelted and be present each day of the trapping season. Sooter (1946) has suggested the width of the upper incisors at the gum line as a possible criterion of age, but this presents much the same disadvantage as does Errington's method—namely, that the investigator must have access to the carcasses. It was in an effort to test the validity of these methods in Missouri, as well as in the hope that more convenient methods might be found, that this study was begun.

The most expedient method of age determination would eliminate the necessity of the investigator being present when the trapper skins his catch. The stretched pelts offer a solution to this problem. Since most trappers allow their pelts to accumulate before selling them, one or two visits to each trapper during the season would yield age data from a sufficient number of animals to give a valid picture of the population composition. This would not only save time but would also enable a single investigator to collect data from several localities during the same season. Lay (1945) used the length of the cased pelt as an age criterion for classifying muskrats of the Texas marshes. As explained below, this method is not applicable to Missouri muskrats because of the degree of overlap in the pelt lengths found in the two age groups.

The method of age determination described in this paper relies principally

upon the primeness pattern of the dorsal side of the cased pelt. No measurements are necessary since data are obtained through visual inspection. The sex ratio can be obtained at the same time by merely noting the presence or absence of mammary glands, as suggested by Buss (1941). Sex and age ratios can be recorded at the rate of 200 individuals per hour, with 100 percent accuracy for sex and approximately 90 per cent accuracy for age. With the assistance of a recorder, several thousand pelts can be examined per day.

#### METHODS

During the summer of 1946, the author and George C. Arthur live-trapped, tagged, and released 208 muskrats. The age of these animals was established at the time of tagging since, in nearly all instances, the young were tagged as kits and all others were obviously adults at that season of the year. One hundred eight of these were taken near Columbia, Missouri, between June 6 and August 19, 1946, and 100 from the Squaw Creek Migratory Waterfowl Refuge in northwestern Missouri during the first two weeks of September. All animals were tagged, using the method of Aldous (1946). Seventy-five of these were retaken during the trapping season, of which sixty-nine (33 from central Missouri and 36 from Squaw Creek) were inspected as to pattern of primeness and served as a basis for determining the validity of the method. Sketches were made of pelts from the Squaw Creek Refuge, while the skins from central Missouri were photographed with a  $2\frac{1}{4} \times 3\frac{1}{4}$  plate camera equipped with a red filter.

During the 1946 trapping season, the author had the opportunity to investigate 1070 pelts from the Squaw Creek Refuge, having in mind the possibility of determining age by means of primeness patterns. Four hundred fifty-five of these animals were checked by four different methods: Errington's, Baumgartner and Bellrose's, Lay's and the primeness-pattern. The remainder of the 1,070 individuals were examined for primeness pattern alone.

#### PELT-PRIMENESS METHOD

Although he did not suggest this difference as a means of age classification, Lavrov (1944), working on muskrats from the Vologda and Archangelsk regions of Russia, first noted the difference in primeness patterns of adult and young muskrats. Lavrov was primarily interested in the moult of muskrats and found that young animals have two distinct moults per year, while the adults moult continuously throughout the year. Although Gunn (1932) and Hamilton and Cook (1946) have explained the phenomenon of priming as a migration of pigment from the hair follicle to the distal portion of each hair, the relationship between the priming process and moult has not been worked out for muskrats. Kellogg (1946) pointed out the variety of primeness patterns of muskrats and suggested that the patterns of primeness might be indicators of age.

Since Russian literature is not readily available in this country, it seems advisable to reproduce here Lavrov's (1944) plate showing patterns of primeness (Figure 1). Lavrov divided his animals into three age groups: young of the first litter; young of the second (summer) and third (fall) litters; and

adults. In Figure 1, the six pelts of young animals were those of the first litter. Lavrov points out that by September the young of the second litter show primeness patterns identical to those of the young of the first litter and that throughout late fall and winter the patterns remain similar. The young of the third litter undergo only one moult, at the conclusion of which there is no further change during the winter. That is, the winter pattern of the third litter would be the same as the pattern which the first litter exhibits in August (Figure 1). The remaining three skins shown in Figure 1 are from adult animals one year or more of age. Lavrov has shown that adult animals moult continuously throughout the year and therefore invariably show a spotted pattern of primeness. The difference in the primeness patterns of young and adult muskrats from Russia is identical with that found in Missouri.

There are not sufficient data at hand to show whether Missouri muskrats breed in their first year. Therefore, at the time of the legal trapping season in December, only two age classes could be established: adult—animals which

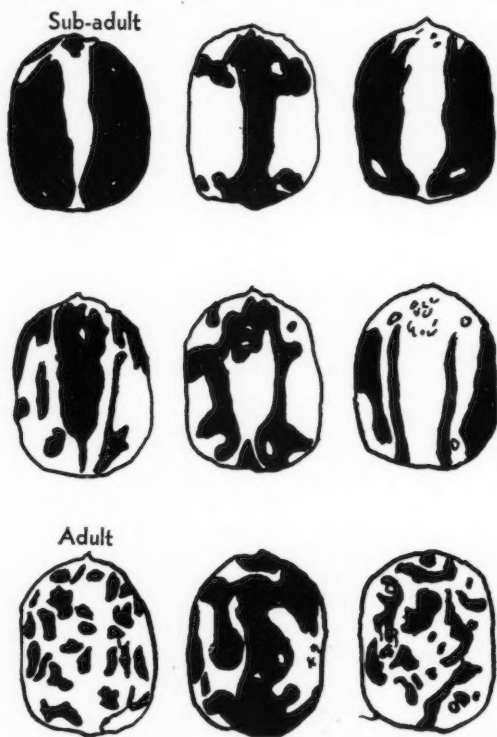


Figure 1. Patterns of primeness of muskrat pelts from Russia. (Reproduced from Lavrov, 1944).

have reached sexual maturity, and sub-adult—animals which have not become sexually mature. The majority of primeness patterns are definitely one of two types: first, the symmetrical pattern of the sub-adult; second, the mottled pattern of the adult. Very young animals (kits) show either a symmetrical pattern or are almost entirely unprime. In plate 2, A, D, and E are typical adult patterns. A is from an adult female tagged June 4, 1946; she was retaken November 12, 1946, (at this time autopsy revealed 15 placental scars). D and E, untagged animals taken December 3, 1946, were aged by Errington's method. Plate 1 shows the variety of typical juvenile (sub-adult) patterns. Pelts A, B, C, and D are from tagged individuals. A and B are from animals tagged August 6, 1946, and retaken December 1 and November 15, 1946, respectively; C is from a juvenile tagged July 6, 1946, and retaken December 2, 1946, and D is a young animal tagged September 25, 1946, and retaken November 12, 1946. The remaining individuals of Plate 1 are from untagged specimens aged by Errington's method. Evidence to be cited shows that 90 per cent of all pelts were of these two general types of pattern.

The remaining ten per cent are characterized primarily by an intermediate primeness pattern which is neither symmetrical nor mottled in appearance. In Plate 2, B, C, and F are characteristic of this type. Pelt B is from an adult female tagged July 30, 1946, and retaken December 3, 1946; C is from an adult female tagged July 2, 1946, and retaken December 2, 1946. The number of placental scars indicated that each of these females had borne two litters in the summer of 1946. Pelt F is from an adult male which was aged by Errington's method. It is possible that the females of this group can be classified according to the appearance of the mammary glands on the flesh side. If the mammae appear blackened, possibly an indication of young having suckled, the animal is probably an adult. If the mammae are unpigmented, the animal is probably sub-adult. In the case of males exhibiting this pattern, the appearance of the ventral side of the pelt can be utilized. If this side is completely prime, completely unprime, or intermediate in pattern like the dorsal side, the animal is considered sub-adult; but if mottled or splotchy in appearance the animal is probably adult. It is this group which introduces the greatest potential error into the method.

As shown below, results obtained by using pelt primeness alone to classify 69 individuals of known age indicate a high percentage of accuracy. This does not, however, present a true picture, for instead of only one individual five

	Age ratio	
	Adult	Sub-adult
Known age .....	15	54
Primeness Pattern .....	16	53

of the 69 were actually classified incorrectly by the pelt-primeness method. These five consisted of three adults which were classed as young and two young classed as adult. Judging from this sample, the pelt-primeness method of age classification does not exceed 93 per cent accuracy.

It should be emphasized that in using this method of age determination the investigator should not let his decision be influenced by the size of the pelt,

especially for animals of intermediate size. It was found that the only animals which could be conclusively classified as to age by size of pelt were the very young, but it was also determined that in these cases the pelt pattern was always distinctly of the very young type. The use of size as a criterion in older animals leads only to confusion and probable error. Therefore it can be safely said that when using the pelt-primeness method of age determination no other factors need be considered.

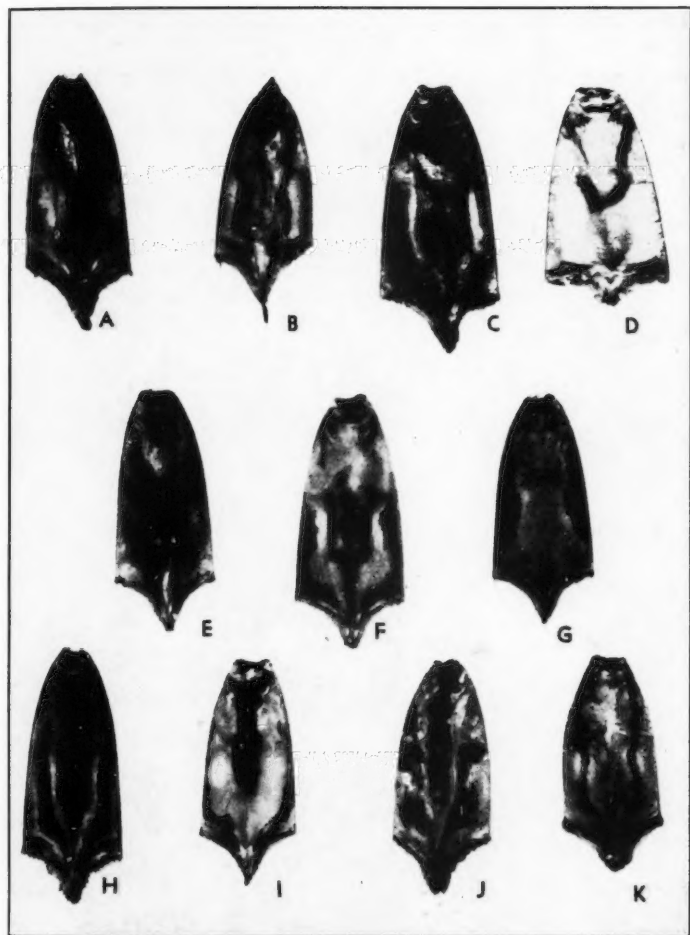


Plate 1. Patterns of primeness of muskrat pelts from central Missouri. Sub-adult.

## VALIDITY OF VARIOUS AGING METHODS

Four hundred fifty-five animals examined during the first ten days of December, 1946, were classified by the pelt-primeness method and also by means of the reproductive tract as suggested by Errington, by the appearance of the external genitalia described by Baumgartner and Bellrose, and the length of the pelt as explained by Lay. The results of this comparison are shown in Table 1 and Figure 2. Examination of Figure 2 shows that the overlap in pelt lengths of Missouri muskrats is so great that for practical purposes Lay's

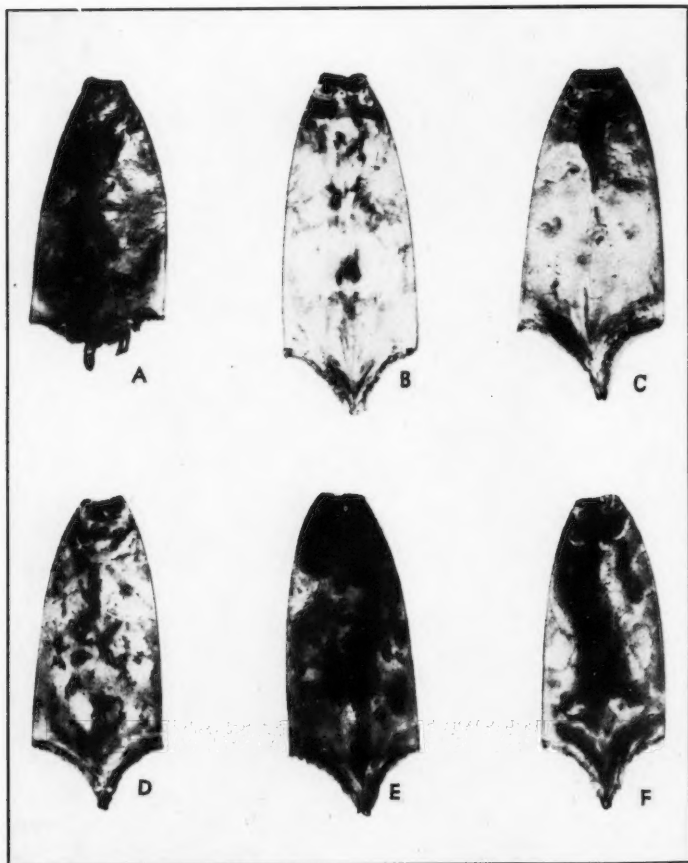


Plate 2. Patterns of primeness of muskrat pelts from central Missouri. Adult.

TABLE 1.—455 animals aged by pelt-primeness, Errington's, and Baumgartner and Bellrose's methods. Squaw Creek Refuge, Dec. 1-10, 1946.

Method	Adult	Sub-adult	Total	
	M : F	M : F	Adult	Sub-adult
Pelt-primeness .....	# : 48:48	194:165	96	359
	% : 50:50	54:46	21	79
Baum. & Bellrose .....	# : 72:71	170:142	143	312
	% : 50:50	54:46	31	69
Errington .....	# : 53:68	189:145	121	334
	% : 44:56	57:43	27	73

method of age determination can not be used in this state. The other three methods are of nearly equal validity (Table 1). Using Errington's method as a basis, it is easily seen (Table 1) that the main source of error in the primeness method results from misleading female patterns. This difficulty may be partially explained by the presence of barren adult females, which retained juvenile patterns in six out of seven cases. Barren females were diagnosed as such when the uteri were adult in appearance (large, thickened, and opaque) but showed no placental scars. Errington (1940) found that 5 per cent of the adult females in Iowa were barren, while in Missouri it was found that 10 per cent of the adult females (7 out of 68) taken in 1946 had apparently failed to conceive. This group accounts for approximately one-third of the adult females which were incorrectly classified by pelt-primeness.

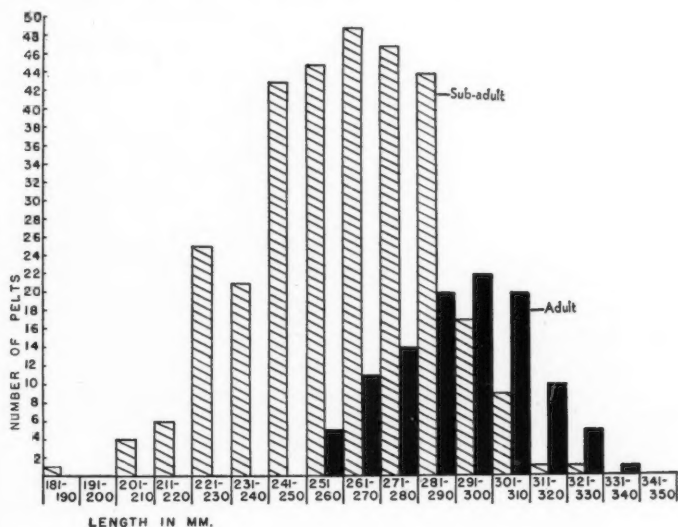


Figure 2. Pelt lengths of adult and sub-adult muskrats from Missouri.



Although Errington (1937) has shown that muskrats do not breed in their first summer in Iowa, it is possible that in Missouri the young of the first litter may breed in August, especially in a year with an early spring, such as 1946. If this is true, these individuals would be classed as adult by Errington's method and as young by the pelt-primeness method. Evidence of this type of error is shown by 16 animals which exhibited typical juvenile patterns and possessed placental scars. Thirteen of these had seven or fewer placental scars, indicating that they had borne but one litter. The remaining three of these with juvenile pattern had 11, 15, and 31 placental scars respectively. With the exception of these three individuals, all females examined which showed evidence of having borne two or more litters also exhibited a typical adult pattern of primeness.

With regard to Errington's method, Baumgartner and Bellrose (1943) have stated that "the internal characters were confusing in some individuals . . ." The same difficulty was experienced with some Missouri muskrats, especially males. These were also the animals found difficult to classify by the pelt-primeness method.

Among the 455 animals aged by the various methods, disagreement was found between the pelt-primeness method and Errington's method in 41 cases. The two methods agree in 90 per cent of the cases.

#### SUMMARY

1. Pelts from muskrats in Russia exhibit distinct differences in pattern of primeness associated with age. The same differences were found in Missouri.
2. On the basis of present knowledge, Missouri muskrats may be divided into two age classes: sexually mature and sexually immature.
3. These two age classes can be distinguished by inspection of the pattern of primeness, a symmetrical pattern denoting sub-adults and a mottled pattern adults.
4. Errington's and Baumgartner and Bellrose's methods of age determination were found to be valid for Missouri muskrats, but more laborious and time-consuming than the pelt-primeness method.
5. Lay's method of age determination based on the length of stretched pelts was not reliable for Missouri muskrats.
6. The pelt-primeness method of age determination offers a means of acquiring mass statistics as to age and sex composition of large muskrat populations. The method may possibly apply to certain other furbearers.

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## Ficus In Florida—II. African Species

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### Introduction

This series of studies, like its predecessor\*, is intended to bring up to a recent date the most important information concerning a few species of fig trees, and to serve as a point of departure for future work on specimens of these trees which may be collected by post-war botanical expeditions.

Therefore the synonymy of each species has been collected and evaluated, and detailed descriptions made from living trees in Florida, herbarium material, and literature. The field work has been done principally at Chapman Field, the United States Plant Introduction Station south of Coconut Grove; the McKee Jungle Gardens, Vero Beach; Woodlawn Cemetery, Miami; the Cypress Gardens, Winter Haven; and the Royal Palm Nurseries at Oneco. Specimens have been seen also on private estates, such as those of Mrs. Charles T. Simpson in Miami, and the Peace Jungle Gardens, Fort Myers; and along streets. Herbarium specimens have been studied at the New York Botanical Garden, New York City; the Arnold Arboretum, Jamaica Plain, Massachusetts; the United States National Herbarium, Washington; and the University of Florida, Gainesville. Most of the literature was examined at the New York Botanical Garden, but some was seen at the Arnold Arboretum.

I am very grateful to those who allowed me to use these facilities, and particularly to Mrs. Simpson, Mr. Gaines R. Wilson of Coconut Grove, and others in the gardens and nurseries who acted as guides.

### *Ficus afzelii* vs. *Ficus eribotryoides*

For the last hundred years a certain African species of *Ficus* has gone by two names, *F. afzelii* and *F. eribotryoides*: the first a sort of trade name and the second employed mainly by taxonomic botanists. Most writers have shown in synonymy that the two titles apply to the same plant, but they have not all agreed as to which was valid and which was a synonym.

The purposes of this study are (1) to demonstrate the valid specific name, (2) to justify or explain the synonyms cited, (3) to make two new combinations, (4) to compile a detailed description drawn from literature and from two trees growing at Chapman Field and at Punta Gorda, Florida. Nehrling's notes (My Gard. Florida 1:322. 1944) state that he introduced this species into Florida.

*FICUS AFZELII* G. Don ex Loudon, Hort. Britt. ed. 1: 416. 1830.

*F. eribotryoides* Kunth & Bouché ex Kunth, Ind. Sem. Hort. Berol. 1846: 14. 1846. ? *F. princeps* Kunth & Bouché ex Kunth, *Ibid.*, fide Mildbraed & Burret.

\* *Ficus* in Florida—I. Australian Species. Am. Midl. Nat. 36: 412-430. S. 1946.

? *Urostigma princeps* (Kunth & Bouché) Miq. Hook. Lond. Jour. Bot. 6: 533. 1847.  
*U. eriobotryoides* (Kunth & Bouché) Miq., *Ibid.* 587. *F. lanigera* Warb. Engl. Bot. Jahrb. 20: 162. 1894. Not Wallich. *F. buchholzii* Warb. ex Mildb. & Burr. Engl. Bot. Jahrb. 46:242. 1911. *Nomen nudum*.

Tree becoming 20-25 m. high in Africa, crown broad, hemispherical; in Florida small trees have gray, slightly furrowed bark showing scars; twigs thick, sometimes flattened, young ones densely white- or rusty-shaggy, becoming bare and red-brown and rusty-scurfy; terminal buds to 3 cm. long, bearing red-brown, velvety, ovate-triangular, elongating caducous stipules; leaves spiral, crowded at apex of twigs; petioles rather thick, 1/6 to 1/5 the length of the blade, to 7 or 8 cm. long, hairy to bare, scurfy and red-brown; blades leathery, but not very thick for their size; oblanceolate, narrow obovate, or (rarely) oblong-elliptical (broader in proportion to their length in variety *latifolia*); the largest usually 22-38 x 7-16 cm. (examples: 30 x 12.5, 32 x 12, 37 x 12 cm.); apex rounded or gradually narrowed, ending in a short, thick, eventually obtuse acumen a few mm. long; base gradually narrowed or cuneate, obtuse or rounded or barely subcordate at the petiole, but with no overlapping lobes; margin flat when dry, entire; upper surface reddish-purple when young, becoming light green and glossy, turning dark when dry; under surface bearing long white or yellowish hairs, eventually almost bare in the interveins, sparsely hairy on the midrib and lateral veins (persistently red- or gold-hairy in var. *caillei*); midrib light-colored when fresh, barely raised or depressed on upper surface, prominent and about 4 mm. thick at the base on the under surface, continuous to apex; basal veins of about the same thickness as the largest lateral veins; the latter light-colored when fresh, in 14-16 or 20 sets, upper angle at midrib 65°-70° near base of blade, 45° near apex, curving up slightly near midrib, abruptly near margin, upper veins forked and united to make an infra-marginal vein, lower veins connected with consecutive laterals by faint transverse veinlets; no prominent tertiary veins, but a zigzag line through each intervein, made by the joining of two rows of large reticular spaces; reticular spaces divided at least twice; background checkered, appearing pitted when dry; figs axillary, sessile, almost globose, 1.5-4 cm. in diameter, densely yellow- or red-hairy, sometimes becoming glabrous; apical bracts not visible; basal bracts two, large roundish, hairy, at first forming a cup, more or less deciduous; male flowers said to be pedicelled, three acute, linear-lanceolate perianth parts and one stamen; female flowers sessile, style short, stigma thick; gall flowers pedicelled.

Type: *G. Don* s. n. Sierra Leone, Africa. (1822-1823).

Distribution: Africa: coast of the Gulf of Guinea from Sierra Leone east to the Cameroons and French Equatorial Africa, thence east across the Belgian Congo to northern Tanganyika, and southeast to Mozambique.

*Ficus afzelii* G. Don ex Loudon var. *caillei* (A. Chevalier ex Mildbraed & Burret) M. F. Barrett, comb. nov.

*F. monbuttensis* Warb. Warb. & DeWild. Ann. Mus. Congo II, 11. pl. 25. 1904.  
*F. eriobotryoides* var. *caillei* A. Chev. (*nomen nudum*) ex Mildb. & Burr. Engl. Bot. Jahrb. 46: 242. 1911. *F. eriobotryoides* var. *monbuttensis* (Warb.) Lebrun, Esp. Cong. Fic. 57. 1934.

This variety was described from sterile material. It differs from type specimens in its denser and more permanent red or gold pubescence on the under surface of the blades.

Type: *A. Chevalier* 12989. Bed of the Ditinn river, French Guinea. Ap 1905.

Distribution: French Guinea, Nigeria, Belgian Congo.

*Ficus afzelii* G. Don ex Loudon var. *latifolia* (Hutchinson) M. F. Barrett, comb. nov.

*F. eriobotryoides* var. *latifolia* Hutch. in Prain, Fl. Trop. Africa 6<sup>2</sup>: 161. 1916.

Hutchinson described broad blades, rounded or subcordate at the base. These basal characters have been found also in type specimens of *F. afzelii*; the breadth, not being specified by Hutchinson, can not be checked.

Type: *Mildbraed* 6517, 6523. Island of Annobon (off the coast of French Equatorial Africa.

Distribution: (above).

#### Validity of the Name *Afzelii*

Kunth described as *F. eriobotryoides* a tree from the collections of the Berlin Royal Garden. Evidently the specimen was small, for neither height nor figs were mentioned. In fact, if the latter had been present they might have instigated a different specific name; for although they are woolly they are not borne in clusters.

A synonym cited was "*F. Afzelii* Hort. Berol. 1846, nec ? G. Don." In other words, this specimen had been suspected to be of the species which George Don had so named and which Loudon had published. Kunth apparently differed from this opinion, perhaps because of his ignorance of the type locality of the Berlin tree. This is shown by his use of the word "patria?" after his description of *F. eriobotryoides*.

George Don had collected during 1822-1823 in Sierra Leone for the Royal Horticultural Society, and his species had been introduced into England in 1823. The specific name referred to Adam Afzelius, who had collected in Sierra Leone from 1792 on. Vernacular English names for this tree are Afzelius's Fig, and Old Calabar Fig.

When Miquel (1847) transferred *F. eriobotryoides* to the new genus *Urostigma* he quoted Kunth's text and the horticultural name, question mark and all. Later (Fic. Afr. 149-150. 1849), although he put *U. eriobotryoides* under doubtful African species he said that he saw dried specimens of *F. Afzelii* Hort. Berol. "an et Don?" He declared that he had not discovered where the latter had been described, but thought that it probably came from "Guinea" (the old name for the territory bordering the Gulf of Guinea). In 1867 Miquel relinquished *Urostigma* as a genus and cited *eriobotryoides* under *Ficus* (Ann. Mus. Bot. Lugd.-Bat. 3: 288).

Later botanists, such as Mildbraed & Burret and Hutchinson, ignored the doubt expressed by Kunth and Miquel and wrote the authorship of this synonym of *F. eriobotryoides* as *F. Afzelii* Hort. Berol. ex Kunth & Bouché. Few writers seem to have credited the authorship to George Don.

But was the Berlin fig-tree the same as the one in England? If so, the assumption of the synonymy in this paper is partly correct, and Don's title is prior to *F. eriotbotryoides*. There is very little evidence on the subject, but the following points have some significance.

First, specimens of *F. eriotbotryoides* have been reported by Mildbraed & Burret as collected from Sierra Leone (*Elliot 5017*), the native home of *F. Afzelii* G. Don.

Second, although Mildbraed & Burret (Op. cit.: 261) separate the synonym *F. Afzelii* from *F. Afzelii* G. Don and place the latter under doubtful or unseen African species, Hutchinson (Op. cit. 6<sup>2</sup>: 214. 1917) while also separating the two, thinks that Don's specimens probably belong to *F. eriotbotryoides*.

Third, of minor importance is the fact that specimens of a plant sometimes appeared in several botanical gardens within the space of a few years. If *F. afzelii* had come to Berlin the same year in which it reached England it would have been too late to be included in Link's enumeration (1822) of the plants in the Berlin Garden and might have had to wait for Kunth's summary (1846) of the species of *Ficus*.

Fourth, the unusual specific name *afzelii* is only a poor argument in favor of the identity of the German and the English species, since *F. brassii* Hort. Berol, given by Kunth & Bouché as a synonym of *F. princeps* (below) apparently differs from *F. brassii* R. Brown ex Sabine, a synonym of *F. capensis* Thunb.

In spite of the paucity of affirmative evidence this paper asserts that the two *F. afzelii*'s are the same. However, to establish Don's name it is necessary to believe that Loudon's mention of it constituted valid publication.

Mildbraed & Burret (p. 261) and Hutchinson (p. 214) speak of Loudon's text as listing only the name. But Loudon's tabulation shows in divisions and in column headings the following characters of "Afzelius's" fig-tree: evergreen, ornamental, 15 ft. high, flowering in April; leaves smooth, oblong, entire. The same characters except the height were listed also for eleven additional species of *Ficus*, which, however, all came from different places than Sierra Leone and had been introduced in other years. Some showed by their specific names that they differed from *F. afzelii*. One other tree came from Africa, from "Guinea", but had small receptacles.

These characters may not differentiate the species completely, but they refer to at least one actual plant which later was listed in Sweet, Hort. Britt. ed. 3: 606. 1839 in much the same form and words as Loudon's. Considering the briefness of many early descriptions of *Ficus* this of Loudon's is acceptable, and the name stated by him should stand for the species.

#### Alleged Synonyms

The alleged synonyms of *F. afzelii*, usually called *F. eriotbotryoides* in the following references, fall into three groups according to their connection with *F. eriotbotryoides*, *F. princeps*, or variety *callei*.

GROUP 1. This contains the *eriobotryoides* synonyms and also *F. lanigera* and *F. buchholzii*, both of Warburg. *F. lanigera* came from Bukoba on Lake Victoria, Tanganyika, Stuhlmann 1449, and 3280. It differed from typical specimens only in its almost bare stipules and its oblong-elliptical, slightly smaller leaves, which were broadest near the middle. This name has been accepted as a synonym by Mildbraed & Burret and by Hutchinson. *F. buchholzii* was *nomen nudum* and apparently had been given to specimens collected by Buchholz in the Cameroons. Mildbraed & Burret listed this synonym, but Hutchinson omitted it.

GROUP 2. The description of *F. princeps*, from Brazil, followed immediately after that of *F. eriobotryoides* in Kunth (1846). Synonyms cited for it were *F. brassii* Hort. Berol. 1846, *F. murrayana* Hort. Berol. 1846, and *F. brasiliensis* Cel. in Desf. The specific name of the last synonym had already been used before its publication by Desfontaines. Miquel (1847) transferred *princeps* to *Urostigma* and added *F. longifolia* Schott. to the synonyms. This he removed when he returned *princeps* to *Ficus* (Ann. Mus. Bot. Lugd.-Bat. 3: 298. 1867).

Miquel's description of *F. princeps* varies slightly from that of Kunth. Both picture, in words, leaves with longer petioles than those of *eriobotryoides* and with blades 37.5 cm. or more in length. Kunth gives the width as 11.5-12.5 cm. and the number of large nerves as 5-7. Miquel omits the width and lists the nerves as 12-16. Kunth omits the receptacles. Miquel describes them as the size of a large pea, bare, with a two-lobed involucre and a peduncle 1 cm. long. Other characters agree well enough with those of *F. eriobotryoides*. Petioles 12.5-14 cm. long (Kunth) have not been reported by other writers or seen by me; but leaves 37 x 12 cm. were measured by me in Florida, and Nehrling (*Op. cit.*: 326) has reported them to 50 cm. long. The receptacles described by Miquel are different from those of *F. eriobotryoides*. Nevertheless Mildbraed & Burret have declared that the herbarium material in Berlin of *F. princeps* was the same as the garden material of *F. eriobotryoides*, and that Kunth's account of only 5-7 sets of nerves was incorrect. They believed that *F. princeps* came from Africa and not from Brazil, and therefore listed it as a synonym of *F. eriobotryoides*, although they omitted its own synonyms.

GROUP 3. To var. *caillei* of *F. eriobotryoides* Hutchinson added the synonym *F. monbottensis* Warb., and increased the details of the distribution to include Nigeria and the Belgian Congo. Warburg's species was based on a sterile specimen, *Schweinfurth III: 157*, from Monbattu in the Belgian Congo. His description and plate prove the allocation correct. Lebrun has reversed the names of the variety and its synonym.

### **Ficus bussei**

Living trees of this species were studied at Woodlawn Cemetery and at Chapman Field. Typical specimens are characterized by their large, stalked figs; and their hairy, long-petioled leaves with overlapping basal lobes and 9-12



sets of large lateral veins. The species is not widely distributed in Africa. It has been introduced in St. Croix (West Indies) and Puerto Rico.

FICUS BUSSEI Warburg ex Mildbraed & Burret, Engl. Bot. Jahrb.. 46: 213. 1911.

Tree to 15 m. high in Africa; aerial and prop roots sometimes present; trunk red-brown in youth, with horizontal ridges and some furrows; branches spreading, thick, hairy to bare, scarred and wrinkled, forming a broad flat-topped crown; twigs green, about 1 cm. in diameter, light-hairy; stipules of terminal bud to 12 mm. long, green shining, bare; petioles to 12 cm. long, about 1/4 to 1/3 the length of the blade, hairy; blades elliptical or ovate-elliptical, or (rarely) obovate-elliptical, large, length more than twice the greatest width (examples: 32 x 15, 25 x 12 cm.), membranous at first, becoming thick, stiff when dry; apex gradually narrowed from the middle of the blade or below, obtuse, not acuminate; base broad, slightly cordate, with rounded, usually overlapping lobes; margin entire, more or less revolute when dry; upper surface light-hairy at first, becoming bare except on the midrib and the largest lateral veins, veining rather indistinct; under surface retaining hair on the veins, which are very prominent; midrib becoming 5 mm. thick at the base; one large pair of basal veins of the same thickness as the largest laterals, the two veins making an upper angle of 110°-135°, sometimes one or more smaller pairs dropping into the lobes and giving a palmate effect; 9-12 sets of lateral veins leaving the midrib at an upper angle of 60°-70°, straight or slightly curved, parallel to one another and sometimes to the largest basal pair, bending toward the apex a few mm. from the margin and connecting with the adjacent veins by short transverse veins; interveins divided into two rows of large reticular sections by transverse veinlets at almost a right angle to the lateral veins, rows meeting in a zigzag line; smaller reticular units and a checkered background present; figs axillary, usually paired, more or less globose, to 3 cm. in diameter, peduncles 1-1.5 cm. long; no apical bracts visible; basal bracts 2, bare, dark brown, parchment-like, joined into a pilose disk; perianth parts said to be 3-parted, margin cut, shape narrow, apex acute; one stamen.

Type: Busse 1024. Zanzibar, Africa. 14 F 1901.

Distribution: Coast of Zanzibar (typical specimens).

Mildbraed (in Mildbraed & Burret *Op. cit.*) gave with some doubt the name var. *longipetiolata* to his own specimens 2380, 2467, collected at Beni in the Belgian Congo. No figs were present. The leaves had petioles 2/3 the length of the blades. There were no overlapping basal folds. The trees were huge and had broad flat crowns. Mildbraed referred again to this variety in Wiss. Deut. Zent.-Afr. Exped. 2: 184-185. 1914.

Peter (Fedde, Repert. 402: 102. 1932) spoke of var. *pubipes* Warb., but asked where the name was published. He located the type of the variety in Tanganyika. According to him *bussei* was the name given by Warburg to a specimen in the Berlin Botanical Garden.

*Ficus capensis* Thunb.

The name of this species of fig-tree is reminiscent of a part of South Africa long known to civilization; but it is slightly misleading in that the tree which it designates is widely spread over most of Africa. Therefore it is suited to tropical and sub-tropical climates. In Florida living trees (rather shrubby) have been studied at Chapman Field, at the McKee Jungle Gardens, and on several private estates. Occasionally there it has been confused with another species. Herbarium specimens of *F. capensis* and of some of its synonyms have been examined at the New York Botanical Garden and at the Arnold Arboretum.

*F. capensis* has received many different names, mostly from Warburg, because of variations in the amount of hairiness of the organs; in the shape, size, margin and surface of the blade, often differing in the same specimen; in the shape, size, and surface of the receptacle; and in the character of the peduncle. Most of the names proposed up to the time of Mildbraed & Burret were cited by them (Engl. Bot. Jahrb. 46: 195-199. 1911) and were accompanied by a list of examples. Hutchinson (*in* Prain, Fl. Trop. Africa 6<sup>2</sup>: 101-103. 1916) examined many specimens, verified most of the synonyms, added to the list, and made a detailed description of the species. Almost the same synonymy and description are contained in Hutchinson's section of Thiselton-Dyer's *Flora Capensis* 5<sup>2</sup>: 527-528. 1920. Lebrun (Esp. Cong. *Ficus* 29-32. 1934) supplied additional reports and synonyms. Peter (Fl. Deutsch-Ostafrika *in* Fedde, Repert. 40<sup>2</sup>: 92. 1932) contributed more examples, from former German territory.

Hutchinson's appraisal of the specimens and synonyms which he examined usually will be accepted here as the standard for those reported up to his time, since his judgments are more critical than those of Mildbraed & Burret and sometimes are corroborated by Lebrun. Original descriptions which appear to contradict Hutchinson's opinions can not always be relied upon, even when all essential characters of leaves and the exterior of receptacles are included. This is true because of the variations already mentioned, because many synonyms have been based upon and illustrated by only one or two specimens, because of surface changes from youth to maturity, and because there are other species of *Ficus* which are distinguished from *F. capensis* mainly by flower characters, which are omitted from most descriptions. Hutchinson's synonymy here is brought up to a more recent date by the addition of later names.

FICUS CAPENSIS Thunberg, Diss. Fic. 6, 13. 1786. (Not Hort. Berol. 1846).

*F. lichtensteinii* Link, Enum. 2: 451. 1822. *F. brassii* R. Brown ex Sabine, Trans. Hort. Soc. London 5: 448. 1824. (Not Hort. Berol. 1846 ex Kunth. Not Summerhayes.) *Sycomorus capensis* (Thunb.) Miq. Hook. Lond. Jour. Bot. 7: 113, pl. 3 B. 1848. *S. thonningiana* Miq. Fic. Afr. 123. 1849. *S. capensis* forma *guineensis* Miq. Fic. Afr. 124. 1849. *S. capensis* forma *lichtensteinii* (Link) Miq. Fic. Afr. 125. 1849. *S. guineensis* (Miq.) Miq. *in* Hooker & Bentham, Fl. Nigritiana 523. 1849. *F. copensis* var. *guineensis* (Miq.) Miq. Mus. Bot. Lugd.-Bot. 3: 295. 1867. (Not Schweinfurth. Not Hiern?). *F. thonningiana* (Miq.) Miq. Ann. Mus. Bot. Lugd.-Bot. 3: 295.

1867. *F. capensis* var. *trichoneura* Warb. Engl. Bot. Jahrb. 20: 153. 1894. *F. (ycm) us* var. *prodigiosa* Welw. ex Hiern. Cat. Afr. Pl. Welwitsch 4: 1012. 1900. *F. sycomor* var. *alnea* Hiern. *Ibid.* 1013. 1900. *F. sycomor* var. *polybotrya* Hiern. *Ibid.* 1014. 1900. *F. plateiocarpa* Warb. Engl. Bot. Jahrb. 30:292. 1901. *F. capensis* var. *pubescens* Warb. in De Wild. & Th. Durand, Ann. Mus. Congo III, 1: 215. 1901. *F. stellulata* var. *glabrescens* Warb. in Warb. & De Wild. Ann. Mus. Congo II: 27. 1904. *F. villosipes* Warb., *Ibid.* 28. 1904. *F. erubescens* Warb., *Ibid.* 29. pl. 6. 1904. *F. munsae* Warb., *Ibid.* 29. pl. 17. 1904. *F. guineensis* (Miq.) Stapf. in H. Johnston, Liberia 2: 652. 1906. *F. simbilensis*, *F. matabelae*, *F. umbonigera* Warb. ex Mildbr. & Burr. Engl. Bot. Jahrb. 46: 197. 1911. *Nomina nuda*. *F. oblongicarpa*, *F. sericeogemma*, *F. brachypus*, *F. grandicarpa*, *F. sarcipes*, *F. caulocarpa* (not Miquel) Warb. ex Mildbr. & Burr. *Ibid.* 198. 1911. *Nomina nuda*. *F. ostiolata* De Wild. Bull. Soc. Bot. Belg. 52: 220. 1914. *F. ostiolata* var. *brevipedunculata* De Wild., *Ibid.* 221. 1914. *F. beniensis* De Wild. Ann. Soc. Bot. Bruxelles 40: 278. 1931. *F. ituriensis* De Wild., *Ibid.* 281. 1921. *F. mallowocarpa* var. *trichoneura* (Warb.) Peter. Fedde, Repert. 402: 85. 1932. *F. capensis* var. *typica* Lebrun, Esp. Cong. Ficus 31. 1934. *F. capensis* var. *ituriensis* (De Wild.) Lebrun, *Ibid.* 31. 1934. *F. capensis* var. *beniensis* (De Wild.) Lebrun, *Ibid.* 32. 1934. *F. capensis* var. *ostiolata* (De Wild.) Lebrun, *Ibid.* 32. 1934.

Shrub, or tree to 30 m. in height; trunk often thick and low-branching, bark light-colored to darker, smooth to rough, scaly, and fissured; crown broad; twigs glabrous or pubescent to bare, except for pubescence at tip and around stipule scars, sometimes exfoliating; terminal buds conical; stipules hairy to almost or quite glabrous, caducous; petioles 2-8 cm. long, glabrous or glabrescent, rarely pubescent when mature, sometimes scurfy; blades thin-leathery, usually ovate, but sometimes elliptical, to 25 x 12 cm. in size (examples: 10 x 5.5, 13 x 7, 18 x 6, 20.5 x 11.5 cm.); apex usually obtuse or short-blunt-acuminate; base usually rounded or subcordate, rarely truncate or cuneate; margin bearing irregular coarse obtuse or sinuate teeth above the generally entire base, sometimes wavy or entire; upper surface glabrous or glabrescent, sometimes rough; under surface glabrous or glabrescent, or hairy especially on veins and midrib; midrib continuous to apex of blade; one large pair of basal veins reaching halfway up the blade, a very small secondary basal pair forming the boundary of the lower branches of the first pair; 6-8 sets of lateral veins, the 3 or 4 lowest very large, upper angle about 45°, almost straight at first, then curving up parallel to the blade margin, the uppermost uniting directly with the next vein above, the lowest uniting by means of strong transverse veins at almost a right angle; reticulum present, but fine and indistinct; a checkered background present, sprinkled with raised points; receptacles produced in simple or branched grape-like clusters 1.5-10 dm. long on the trunk and the lowest foliage branches; figs turbinate, obovoid, ellipsoid, or globose, 1.3-4 cm. in greatest diameter, glabrous, glabrescent or sometimes hairy, reddish or brown; ostiole prominent at first, then depressed, surrounded by several often hairy bracts forming a 4-sided or star-shaped rosette; three usually hairy and caducous basal bracts forming a triangular or five-sided disk or cup at the rounded or slightly stipitate base of the receptacle; peduncles 3-25 mm. long (usually 6-15 mm.), thick, glabrous, glabrescent or hairy; male flowers subsessile, three perianth parts with obtuse or rounded apex, two stamens, short filaments; female flowers pedicellate or subsessile, perianth parts oblong-lanceolate, acute, glabrous; ovary ellipsoid, style lateral, short, stigma small; gall flowers long-pedicelled.

Type: *Thunberg?* Cape of Good Hope, Africa.

Distribution: Africa from about 15° N south to the southern coast, except south-west Africa.

Common names: Cape fig. Bush fig.

#### Interrelation of Synonyms

The following key has been made from descriptions and plates and the few herbarium specimens of the alleged varieties and synonyms of *F. capensis*. The number of descriptions of most of these forms is small, and even the type characterizations often are incomplete and based upon few specimens, thereby presenting inadequate pictures and trivial distinguishing characters. However, this inaccurate key may serve as a series of brief characterizations and show a sort of spiral relationship rather than a number of definite varieties. *F. riparia* Hochst. ex Rich., thought by Mildbraed & Burret to be one extreme phase of *F. capensis*, has been included here, although Hutchinson rejected it.

#### KEY

1. Shrubs or shrubby when mature.
  2. Blade margin entire or repand, apex obtuse or rounded ..... *alnea*
  2. Blade margin with wide indentations, apex acute ..... *brassii*
1. Trees.
  2. Under surface of blade decidedly hairy when mature.
    3. Receptacles measuring 2.5 cm. or more, sparsely hairy .....  
 ..... (*trichoneura*, *pubescens*) *villosipes*
    3. Receptacles sometimes smaller than 2.5 cm. tomentellous with pale hairs.....  
 ..... *polybotrya*
  2. Under surface of blade hairy only on veins, sometimes glabrescent.
    3. Margin of blade toothed, at least in part; teeth sometimes far apart and obtuse ..... *typica*  
 (Forms under this no. 3 seem to agree best with the type.)
    4. Petioles often more than 2.5 cm. long.
      5. Largest blades more than 15 cm. long.
        6. Receptacles less than 3 cm. long ..... *plateiocarpa*
        6. Receptacles less than 3 cm. long ..... *guineensis* Hiern.
      5. Largest blades not more than 15 cm. long.
        6. Length of blade less than twice width ..... *guineensis* Miq.
        6. Length of blade often at least twice width ..... *lichtensteini*
    4. Petioles to 2.5 cm. long.
      5. Upper surface of blade hairy at first ..... *thonningiana*
      5. Upper surface of blade glabrous ..... *glabrescens*
  3. Margin of blade entire or wavy.
    4. Length of blade usually at least twice width.
      5. Peduncle to 2.5 cm. long ..... *ostiolata*
      5. Peduncle not more than 1.5 cm. long ..... *brevipedunculata*
    4. Length of blade usually less than twice width.

5. Blade usually less than 12 cm. long, receptacle to 3 cm. long ..... *glabrescens*
5. Blade often more than 12 cm. long, receptacle to 4 cm. long ..... *plateiocarpa*
2. Under surface of blade glabrous throughout life.
3. Margin of blade entire or wavy.
  4. Length of blade 2-3 times greatest width, receptacle to 1.5 cm. long ..... *F. riparia*
  4. Length of blade usually less than twice width, receptacle usually more than 1.5 cm. long.
  5. Five or more sets of lateral veins in blade.
    6. Margin entire, base cordate ..... *beniensis*
    6. Margin wavy, base rounded or subcordate ..... *munsae*
    5. Two or three sets of lateral veins in blade ..... *prodigiosa*
3. Margin of blade distinctly toothed or indented, at least in part.
  4. Length of blade more than twice width, base cuneate, stipules glabrous ..... *ituriansis*
  4. Length of blade usually not more than twice width, base rounded or subcordate, stipules hairy.
  5. Petioles to 3 cm. long ..... *erubescens*
  5. Petioles often more than 3 cm. long ..... *munsae*

#### Development of the Concept of *Ficus capensis*

FROM THUNBERG TO MIQUEL

The most complete of Thunberg's descriptions of *F. capensis* is that on p. 13 of his dissertation on *Ficus*, although he mentioned no location other than that implied in the specific name of the tree. Later (Prodr. Pl. Capensium pt. 1: 13. 1794) he stated the distribution as Cape of Good Hope. Schultes (ed. Thunb. Fl. Capensis 34. 1823) located Thunberg's specimens in the South African Essebosch, near the Zeeko River, the Pisang River "and elsewhere."

Between 1786 and 1848, the date of Miquel's first mention of *capensis*, two significant references appeared. Sprengel (ed. Syst. Veg. 3: 783. 1826) cited *F. lichtensteinii* Link as a synonym, and Krauss (Flora 28: 88. 1844) reported specimens of *F. capensis* from Natal Bay. Thunberg's Zeeko River specimen and Krauss 264 have been accepted for *F. capensis* by Hutchinson (1920).

The type of *F. lichtensteinii* was a greenhouse plant which had come to the Berlin Royal Botanical Garden from the Cape of Good Hope and had been named by Link in 1822. Although Link and, later, Kunth mentioned no receptacles their characterizations filled out some gaps in the concept of *F. capensis*, of which *F. lichtensteinii* has been generally accepted as a synonym.

#### MIQUEL'S WORK

In the 1840's Gasparrini and Miquel attempted to divide *Ficus* into several new genera. One of these was *Sycomorus*, based upon the sycomore fig of Egypt and adjoining countries. To this genus Miquel (1848) transferred *F. capensis* Thunb. with its synonym *F. lichtensteinii*. Two new (to him) species were named *S. guineensis* and *S. thoningiana* and well illustrated in

plates 14 B and 14 A, but no descriptions were made: therefore the names were not validly published. The descriptions were to have appeared in *Flora Nigritiana* by J. D. Hooker and George Bentham; and probably already had been written by Miquel. However, the publication of that volume, and consequently of the two new species was delayed until the latter part of November 1849. In the meantime Miquel had written a paper on African fig-trees which was printed in 1849 in a Dutch publication. In this he made his first description of *Sycomorus Thonningiana*. He also characterized *F. lichtensteinii*, using the specimens upon which he had based *S. guineensis* in 1848, and remarked that *lichtensteinii* made a transition from *S. capensis* to forma *guineensis*. This chronology explains why *guineensis* appeared first as an invalidly published species, then as a forma of *S. capensis*, and still later as *S. guineensis*.

Miquel made two other allocations of *guineensis*. In 1851-1853 (Pl. Iunghuhniana 64) he cited *S. guineensis* from Java as the type of *S. capensis* forma *tropica*. But this specimen, as he acknowledged in 1867 (3: 295), was an example of *F. variegata* Blume. By 1867 Miquel had abandoned *Sycomorus* as a genus and declared that *guineensis* was a variety of *F. capensis*. His descriptions spoke of a larger, more hairy tree than his conception of *F. capensis*. Its leaves had longer petioles, and larger blades with a slightly narrowed base. Type specimens were Vogel 48 and 27 from Cape Palmas in what is now Liberia.

*Ficus guineensis*, referred to by Warburg (Engl. Bot. Jahrb. 30: 292. 1901) as like *F. kondeensis* in leaf-form, was not validly published, because the name of Miquel was omitted. This is on the supposition that Warburg had decided that *guineensis* was a species and not a variety of *F. capensis* as he had admitted in the above periodical in 1894 (20: 153). If he had made a new species with that specific name he would have appended his own name. Stapf and others have used the title *F. guineensis*, and the specific name in one or more of its allocations has been accepted as a synonym of *F. capensis* by Mildbraed & Burret, Hutchinson, and Peter.

There is a question about a report of *F. capensis* var. *guineensis* from Angola made by Hiern (see synonymy) 1016-1017, but allocated to *F. mallotocarpa* Warb. by Hutchinson (1916) 97. According to Hiern's description specimens Welwitsch 6410 and 6422 resemble *F. mallotocarpa* in some respects, but are merely pubescent instead of having the long light-colored hairs on various organs which are characteristic of Warburg's species. *F. mallotocarpa*, Robyns 1809, a specimen approved by Lebrun for that species and seen in the herbarium of the New York Botanical Garden, differs decidedly from Hiern's characterization, and from *F. capensis*, to which Mildbraed & Burret assigned it as var. *mallotocarpa*.

Type specimens of *S. thonningiana* were numbered 78, 78 C, and 76. They had been collected by Vogel on St. Vincent, one of the Cape Verde Islands. The species was returned to *Ficus* by Miquel (1867) and has been listed as a synonym of *F. capensis* by Mildbraed & Burret and Hutchinson.

*F. brassii* was cited as a synonym of *S. capensis* by Miquel (Fl. Nigrit. 523). Specimens had been obtained in Sierra Leone by George Don. The specific name was derived from another collector, William Brass, who had

found the same form on the "Cape Coast". Miquel had some difficulties with its spelling and authorship, and eventually (1867) allocated it to *F. capensis*. Mildbraed & Burret and Hutchinson have so accepted it.

The name *Ficus riparia* originally was an unpublished one given by Hochstetter to specimen III, 1585 in Schimper's collection of the plants of Abyssinia. Miquel (1848) 7: 114 described it as "*Sycomorus ? riparia*" and referred to Hochstetter. The species was published as *F. riparia* Hochst. ex Richard in 1851. Most of its characters agree with those of the variable *F. capensis*; but the small receptacles, 1.3 cm. in diameter, the narrow leaves, and the location in Ethiopia seem to indicate a separation from the Cape fig. Mildbraed & Burret, who examined the type, have considered it an extreme phase of *F. capensis*; but Hutchinson (1916) 100-101 has classified it as an independent species.

#### WARBURG'S SPECIES

There seem to have been few published reports of *F. capensis* or its synonyms between Miquel's of 1867 and Warburg's African papers of 1894, when the latter printed an inadequate description of var. *trichoneura*. Of this Warburg said only that it was pilose on the nerves of the under surface of the blade. The specimen was *Stuhlmann I*, 797, from Zanzibar Island. Mildbraed & Burret added it to the synonymy of *F. capensis* with a question mark and the note that it included var. *pubescens* Warb. Hutchinson has considered it a synonym, but Peter believed it a variety of *F. mallotocarpa*, although he included Stuhlmann's specimen under *F. capensis*.

Warburg's description of var. *pubescens* also was scanty. The type was *Dewevre 465*, from Lukungu in the Belgian Congo. Later Warburg used the same specimen as the type of *F. villosipes*, a small-leaved tree whose hairiness persisted throughout life except on the twigs. Mildbraed & Burret, Hutchinson, and Lebrun have accepted *pubescens* and *villosipes* as synonyms of *F. capensis*, but Peter omits *pubescens*.

Warburg (Engl. Bot. Jahrb. 28:379. 1900) gave the name *F. capensis* to specimen Goetze 218 from Tanganyika. The next year he stated that he believed that this was the type of a new species, *F. plateiocarpa*, which had large thin blades and big receptacles with green warts on their surface. Mildbraed & Burret declared that the blades were such as probably had grown on watersprouts, and they, Hutchinson, and Peter have allocated *F. plateiocarpa* to *F. capensis*.

*F. stellulata* var. *glabrescens*, but not *F. stellulata*, the typical form, has been cited under *F. capensis* by Mildbraed & Burret, Hutchinson, and Lebrun. Type specimens were J. Gillet 447 and 905, from the Lower Belgian Congo.

The characters of *F. erubescens* Warb. conform in general to those of *F. capensis*. Most of the specimens, from the Belgian Congo, have been accepted for that species by Hutchinson. The three other authorities agree with the allocation, although Lebrun transferred reports of *F. erubescens* by De Wildeman (Mission Ém. Laurent 70. 1905-1907) and by Durand & Durand [Syll. Fl. Congolanae 505 (in part). 1909] to *F. mallotocarpa*. Hutchinson assigned those of De Wildeman to *F. capensis*.



Warburg described *F. munsae* from sterile specimens, *G. Schweinfurthi* 3426 and 3455, from Munsa in the Belgian Congo. Nothing in the description or the plate shows any radical difference from the common form of *F. capensis*, to which it has been allocated by Mildbraed & Burret, Hutchinson, and Lebrun.

Warburg's *nomina nuda*, reported by Mildbraed & Burret, have been accepted also by Hutchinson. In this paper, however, *F. kiboschensis* and *F. kwiensis* have been omitted, since they belong to *mallotocarpa*.

It is a little surprising that Warburg failed to recognize his various new species as *F. capensis* in view of his remark (1894) 20:153 that there are countless varieties of that species from the Cape through Angola and Guinea to Senegambia, and from Natal to German East Africa.

#### HIERN'S DESCRIPTIONS

Hiern thought that three sets of specimens collected in Angola by Welwitsch were varieties of *F. sycomorus*. One, *prodigiosa*, nos. 6368, 6369, had received that unpublished name from Welwitsch. The others were named by Hiern: *alnea*, 6377, 6376, 6367; and *polybotrya*, 6343. The last seems extremely close to *villosipes*. Mildbraed & Burret allocated all three to *F. capensis*, and Hutchinson agreed, although he did not cite Welwitsch's specimens.

Hiern's report of var. *guineensis* already has been discussed.

#### DE WILDEMAN'S SPECIES

Three species proposed by De Wildeman have been considered varieties of *F. capensis* by Lebrun (1934). As all were found in the Belgian Congo they are not included in Peter's text. They postdate the work of Mildbraed & Burret, and only two, *F. ostiolata* and its variety, precede the texts of Hutchinson. Apparently all belong to *F. capensis*, but whether as synonyms or varieties may be debatable.

De Wildeman's attitude towards the making of new species is indicated by his comment in connection with *F. ituriensis*, in which he took issue with Hutchinson's attempts to consolidate various forms. De Wildeman then said that if one united all the forms of *F. capensis* under a single specific name, then subspecies, varieties and *formae* should be made, based on such characters as margin entire or toothed, and blades rounded, cuneiform, or cordate at the base; and that "nothing proves to us that these diverse characters are not constant" (transl.). De Wildeman's species differ as he suggested, so far as his observations of margin and base are concerned; but his conception of constant characters may be challenged, since it apparently depended on only one or two specimens of the type of each species.

The type of *F. ostiolata* was *F. Seret* 312, Gongo Chief's village, Belgian Congo. De Wildeman said that the species was near *F. capensis* but had entire leaves and long peduncles. The description indicates shorter petioles and narrower blades (8-15 x 3.5-7 cm.), and narrower, more nearly ellipsoid receptacles than are found in the common form of *F. capensis*.

The variety, *brevipedunculata*, was created from *F. Seret* 286, Village "Bo", Belgian Congo. A part of the type specimen in the herbarium of the New York Botanical Garden shows hairy or glabrate parts, rather narrow blades, some elliptical with narrowed apex and base, and some typically ovate, measuring 9.5 x 4, 11 x 6, 12 x 5 cm.: all with a finely wavy margin. The receptacle is obovoid but not really stalked, and has a peduncle only a few mm. long.

Both of Seret's specimens have been accepted for *F. capensis*, and the species and variety as synonyms.

The original publications of *F. beniensis* and *F. ituriensis* have not been seen by me, but both were well described in De Wildeman, Pl. Bequaertianae 332-333 and 343-344. 1922.

*F. beniensis* had entire blades with a basal sinus 1 cm. deep and two sets of basal veins. The tree was glabrous except for stipules and peduncles, and the ellipsoid receptacles were narrowed at the base and measured 15-35 x 11-28 mm. The type was Bequaert 5144, from Beni.

*F. ituriensis* was based on J. Bequaert 2184. Penghe. It was entirely glabrous except on some branches of the fructification. The elliptical blades measured 9-15 x 3.2-6.8 cm., were rather abruptly acuminate, and were wide-toothed above the middle of the blade. The receptacles were sub-globose or ellipsoid, 10-12 mm. long, and had a rounded or a slightly stipitate base.

Lebrun (1934) 31 made a short key to De Wildeman's species, which were considered varieties, and also to *F. capensis* var. *typica*. In this *ituriensis* is differentiated by its combination of characteristic blade-shape, -proportions, -apex, -base, and -margin; and *beniensis* by its cordate blade-base. *Ostiolata* is separated from *typica* by its entire-margined blade, which is less ovate than that of *typica*. Var. *brevipedunculata* of *ostiolata* is not mentioned. The New York specimen could not fit into Lebrun's key for *ostiolata*. In 1935 (Ess. For. Congo Or. 65-66. pl. 3.) Lebrun made a description of *F. capensis* Thunb. in which he included the distinguishing characters of his previous four varieties, and omitted mention of the varieties themselves. It is possible that this treatment was occasioned by the character of his text, which was descriptive; whereas that of 1934 had lacked descriptions and had consisted of synonyms and records of specimens, and of a key to the species of *Ficus* in the Belgian Congo.

This summary of variations leads back again to what ordinarily is the starting point in the discussion of a species: the typical form. Var. *typica* of course is that described by Thunberg (1786) and containing the following characters: vast bare tree, branches spreading; leaves ovate-oblong, acute, sinuate-dentate, bare, a finger long; peduncles (petioles?) (equalling) 2.5 cm.; fruit scattered, pedunculate, turbinate, glabrous, size of a hazelnut or more. The reason why this is considered an insufficient characterization is that modifications occur along with organs which conform to Thunberg's description. The commonest form seems to differ from his in greater hairiness, or at least glabrescence, and sometimes in larger leaf dimensions. But, as

Lebrun (1935) has said, the species is common everywhere (in Africa). Therefore variation is to be expected.

*Ficus lyrata* Warb.

This African fig-tree is well known in the United States, and is easily recognizable because of its very large violin- or guitar-shaped leaves. In the northern part of the country it is used as a pot or tub plant, and because of its interesting leaves, its durability, and the ease of its cultivation it has almost superseded the "Rubber Plant," *Ficus elastica*. In Florida it has been grown as a street or a specimen tree in the McKee Jungle Gardens; in Fort Myers near the Royal Palm Hotel, on First Street near the bridge, and on the corner of Route 41 and Victoria Street; in the Cypress Gardens near Winter Haven; at Chapman Field; and at Sanford, Lake Wales and other places.

Although this species received the name *lyrata* in 1894 and has been so known to taxonomic botanists it has been quite generally called *F. pandurata* by horticulturists. Unfortunately this appropriate name is not valid, for it was given by Hance in 1862 (Ann. Sci. Nat. IV, 18:229) to a very different plant, a Chinese shrub with much smaller and less panduriform leaves.

The following synonymy attempts to state correctly the names which this species has received. The description and other data are drawn from living specimens in Florida as well as from herbarium material and literature at the New York Botanical Garden and the United States National Museum.

*FICUS LYRATA* Warburg, Engl. Bot. Jahrb. 20:172. 1894.

*F. pandurata* Hort. Sander ex Gard, Chron. III, 33: 245. 18 Ap. 1903. Not Hance. Not Leveillé & Vaniot. *F. togoensis* Warb. ex Mildbraed & Burret, Engl. Bot. Jahrb. 46: 241. 1911. *F. jollyana* A. Chevalier ex De Wildeman, Bull. Soc. Bot. Belg. 52: 219. 1914.

Tree to 20-25 m. high in tropical Africa, in Florida to 9 m. or more; trunk thick, sometimes buttressed; crown round, to 15 m. in diameter; twig to 1 cm. thick, pubescent to bare, bark cracking when dry; stipules 4.5 x 2-2.5 cm. narrow, acuminate, dark brown, embracing the twig, persistent; petioles 2.7 x 0.3-1 cm., glabrous or hairy; blades reported to 87 x 48 cm. in size, the largest usually about 40 x 25 cm. (examples: 22.5 x 14, 26.5 x 18, 37 x 24 cm.); panduriform or obovate; apex broad-rounded with a very short, thick, abrupt, obtuse acumen, or merely obtuse; base slightly narrowed, deep-cordate with a narrow sinus and lobes sometimes slightly overlapping the petiole; margin entire, sometimes revolute; texture leathery, wrinkling and curling when dry; upper surface bare, dark green, sometimes glossy; under surface bare, dull; large veins depressed on upper surface, very prominent on under surface, light colored when young; midrib very heavy, continuous to apex of blade, a gland at its base; one pair of basal veins about equaling the lateral ones in direction and angle, two or more smaller pairs or branches from the first pair drooping into the lobes; 4-6 sets of lateral secondary veins. decurrent on midrib, upper angle about 60°, straight, then slightly curved upward, forking before margin but not forming an inframarginal vein, con-

nected with adjacent veins by transverse veinlets; intervein containing two rows of large reticular spaces whose joinings form a zigzag line; reticular spaces divided into smaller ones; a checkered background and a reticulum very distinct in dry specimens; figs axillary, paired, sessile, globose, about 4-5 cm. in diameter, rusty-hairy, or crimson with white dots or bare bright spots; ostiole slightly depressed, apical bracts invisible externally; basal bracts usually 3, triangular, 4 mm. long and wide, appressed; flowers said to have a perianth of 3 more or less ovate parts; male flowers having one stamen, with an ovoid, erect anther; female flowers having a short style and a short, suboblique, papillose stigma; according to Nehrling (My Garden in Florida 319. 1944) no seeds were set in Fort Myers, since the proper insects for pollination were lacking.

Type: Preuss 455. Cameroons, Africa. Ag 1890.

Distribution: Cameroons, Togo, French Gaboon, Liberia, Nigeria, Ivory Coast. Cultivated on other continents. Suited to outdoor culture in southern Florida.

Common names: Fiddle-leaf Fig. Fiddle-leaved Rubber Plant (or Rubber Tree). Cameroons Rubber Tree. Lyrate-leaved Fig. Banjo Fig.

#### History

The history of the various names applied to this tree has been partly traced by W. Watson (Gard. Chron. III, 50:234-235. pl. 107, 108. 30 S 1911) and De Wildeman (1914, see synonymy). As *F. lyrata* the species seems to have almost escaped attention for 17 years. It was known, however, for seeds were sent into France by A. Jolly in 1895, and enormous leaves presented by him to L. Pierre probably were the ones which Pierre had in mind when, in 1895, he spoke in manuscript of *F. lyrata*.

When the African seeds sprouted the little plants were distributed to various places. Those which went to the Colonial Garden of Nogent were called *F. pandurata* by Jean Dybowski; but this name apparently was not published. In 1903 Sander & Sons, nurserymen of St. Albans, England, and Bruges, Belgium, exhibited at Ghent plants called by them *Ficus pandurata*. The first item in the synonymy above came from an unsigned report, perhaps by W. Watson, of their display, giving enough description to constitute publication. The plants soon aroused interest in the United States; for notes about them, accompanied by pictures, appeared in American Florist (23:239. 3 S 1904; and 26:203. 24 F 1906), Gardening (Chicago, 16:34. 15 Oct. 1907), Garden Magazine (8:268. Ja 1909), and Apgar's Ornamental Shrubs of the United States 309. 1910. In each case *F. pandurata* was mentioned without author, but the text and the pictures showed that Sander's species was meant.

In 1911 W. Watson (above) published an article entitled "*Ficus pandurata* = *lyrata*" in which he stated that he had seen a plate representing parts of *F. pandurata* Hance, had realized that the Chinese species differed from the one shown by Sander, had looked up the type specimen of *F. lyrata* Warburg

in the Kew Herbarium, and had found that it was the same as Sander's plant. After the appearance of Watson's paper the specific name *lyrata* gradually superseded *pandurata*, or at least was added to it as a synonym.

Of the other names in the synonymy, *F. togoensis*, according to Mildbraed and Burret (above) was given by Warburg to a specimen from Togo. Since he cited this example, although without naming it, in his original description of *F. lyrata* he may have formulated *togoensis* before he proposed *lyrata*. However, *togoensis* was never published.

*F. jollyana* was a manuscript name, and may have referred to specimens collected on the Ivory Coast by Jolly in 1897 or by Chevalier in 1907.

### *Ficus natalensis* and *Ficus dekdekena*

Several years ago leaves were collected in Florida from an African tree labeled *Ficus volkensii*. As this is supposed to be a synonym of *Ficus natalensis* Hochst. ex Krauss, and as the specimens resembled, not that species, but *F. dekdekena* (Miq.) Richard, a distinction between these species, accompanied by a synonymy and a description of each, seems desirable.

*FICUS NATALENSIS* Hochst. ex Krauss, Flora 28:88. 1845.

*F. columbarum* Hochst. ex Krauss, Flora 28: 88. 1845. *Nomen nudum*. *Urostigma natalense* (Hochst. ex Krauss) Miq. Hook. Lond. Jour. Bot. 6: 556. 1847. *U. natalense* var. *minor* Sonder, Linnaea 23: 137. 1850. *F. natalensis*  $\beta$  *minor* (Sond.) Miq. Ann. Mus. Bot. Lugd.-Bat. 3: 289. 1867. *F. volkensii* Warb. Engl. Bot. Jahrb. 20: 167. 1894. *F. chrysocerasus* Warb., *Ibid.* 1894. *F. natalensis* var. *latifolia* Warb. Viert. Nat. Ges. Zürich 51: 142. 1906. *F. natalensis* var. *puberula* Warb., *Ibid.* 1906. *F. durbanii* Warb., *Ibid.* 1906. *F. natalensis* var. *pedunculata* Sim, For. Fl. Port. E. Africa 98, pl. 90 A. 1909.

Shrub or tree to about 15 m. in height; glabrous except sometimes the receptacles, peduncles, and basal bracts; often starting as an epiphytic straggler; trunk sometimes buttressed and bearing prop roots, diameter to 1 cm.; branches light-colored, wrinkled, the largest sometimes bearing air roots; twigs slender, gray or red-brownish; stipules deciduous, linear-lanceolate, acuminate; petioles slender, usually about 1 cm. long, not noticeably exfoliating; blades membranous-coriaceous, entire; obovate, oblanceolate, or sometimes elliptical; 2.5-8 x 1.2-5 cm. (examples: 4.5 x 2, 5 x 2.8, 5.5 x 2.5, 8 x 3.5 cm.); apex rounded (sometimes apiculate at first), obtuse or with an extremely short thick acumen; base usually narrowed from above the middle, sometimes cuneate, slightly decurrent on the petiole or obtuse; upper surface grayish; under surface paler, browner, punctate; veining indistinct on upper surface, a little more distinct on under surface and lighter in color than the rest of the blade, especially when dry; midrib continuing to apex; basal veins present, but short and vague; 5-10 sets of lateral veins, upper angle at the midrib 45°-60°; usually one irregular tertiary vein in each intervein, making a dent in the submarginal vein; reticulum showing cross veining and a few short veinlets parallel to the tertiary vein; sometimes a checkered background present; receptacles axillary, single or paired, slightly obovate or globose, wrinkled when

dry, about 1 cm. in greatest diameter when fresh, 7-8 mm. when dry, sometimes slightly pubescent, yellow; apex mammillate with a transverse crease at first, later flat and with a pore; apical bracts invisible from outside; basal bracts caducous, leaving a 3- or 6-lobed disk, sometimes pubescent; peduncle slender, usually 4-7 mm. long, sometimes pubescent; flowers said to have a perianth of three parts, those of male flowers oblong or ovate, those of female flowers elliptical and rounded or lanceolate and acute; one stamen whose anther equals the filament; style filiform; stigma short, not conspicuous.

*Type:* Hochstetter 276. In woods, Natal, Africa. July 1839.

*Distribution:* southeastern coast of Africa from Zanzibar to Port Elizabeth, also Gold Coast, Fernando Po, Cameroons, Angola, Belgian Congo, Uganda, Kenya, Tanganyika, Nyasaland, and Transvaal.

Krauss (above, and Beitr. Fl. Capland. 151-152. 1846) published Hochstetter's own description of *F. natalensis* with its synonym *F. columbarum*, Hochstetter 288. His brief description of the essential characters has been enlarged by Miquel [(1847 and Fic. Afr. 143-144. 1849)], Warburg, and Hutchinson (in Prain, Fl. Trop. Africa 62:208-209. 1917, and in Thiselton-Dyer, Fl. Capensis 52:538-539. 1925) Peter (Fedde, Repert. 402:104-105. 1932) lists many specimens from the former German East Africa, as Hutchinson had done for other parts of Africa. Most of the above synonymy is found in the latter's texts. But *F. natalensis* Sim, For. Fl. Cape Col. 307-308, pl. 106. 1907, and *F. natalensis* Mildbraed & Burret (above, p. 255) have been discredited by Hutchinson (1925, pp. 537 and 540) who thinks that the former may be a synonym of *F. craterostoma* Warb. ex. Mildbr. & Burr., and that the latter is *F. burtt-davyi* Hutch.

The New York Botanical Garden contains in its herbarium an unnumbered sheet of *F. natalensis*, collected by Kuntze from "Capland"; and an unnamed *Ficus* from the Cameroons, Zenker 838, which agrees with the description and plate of var. *pedunculata* Sim. Similar specimens of typical *F. natalensis* were seen in the herbarium of the Arnold Arboretum, Jamaica Plain, Mass.

#### Synonyms

*Urostigma natalense*. Soon after its publication *F. natalensis* was transferred by Miquel to the genus *Urostigma*, which had recently been made from *Ficus*. Miquel's description added measurements and a few details to those stated by Krauss and listed Hochstetter 276, as well as 254, under "habitat." These specimens and 288 have been accepted for *F. natalensis* by Hutchinson (1925). By 1867 Miquel had given up the idea of *Urostigma* as anything more than a subgenus and had added a variety to the type (above).

*F. volkensii*. This was described by Warburg from specimen *Volkens* 136, Tanganyika, January 1893. Warburg apparently never published a characterization of *F. natalensis*, and so has furnished no basis for comparison of his conceptions of the two species. According to his description of *F. volkensii* this is typical of the form of *F. natalensis* which has obovate, rather small



leaves. His statement of 3-5 basal veins and only 4-5 lateral sets is easily explained by the difficulty of distinguishing apart the faint nerves. The very small basal bracts mentioned may have been the lobes of the disk left by the caducous original bracts. Mildbraed & Burret added the synonym *F. durbanii* to *F. volkensii*, and enlarged the reports of distribution. Hutchinson (1917) declared *F. volkensii* a synonym of *F. natalensis* and accepted Warburg's specimen and another reported by Hiern (Cat. Afr. Pl. Welwitsch 4:1007. 1900) as examples of the latter species. Peter has agreed with this synonymy.

*F. chrysocerasus*. The type was Welwitsch 6357, Angola, Sept. 1858. Hiern (*Op. cit.*: 1005) supplied additional data and modified somewhat the leaf measurements made by Warburg. He also suggested Welwitsch 6383 as another example. According to these descriptions the only real difference from *F. natalensis* is the hairiness of the twigs and peduncles, and even this eventually disappears. Mildbraed & Burret believed that *F. chrysocerasus* was a synonym of *F. dekdekena*. This accounts for Hutchinson's inclusion of *F. dekdekena* Mildbr. & Burr. in part, as a synonym of *F. natalensis*. Hutchinson accepted Welwitsch 6357 but not 6383 as an example.

*F. durbanii*. Type specimens Rehmann 9008 and 9009 from Durban exemplified the oblanceolate form of leaves of *F. natalensis* and a pyriform-globose receptacle. Mildbraed & Burret allocated *F. durbanii* to *F. volkensii*, and Hutchinson placed it under *F. natalensis* although he did not mention the specimens as examples.

#### Alleged Varieties

Sonder listed *U. natalense* from Krakakamma, between Port Elizabeth and Van Stadeberg in southeast Africa, *Jul. Ecklon & Zeyher, Urtic. 6*. On the same page he characterized *U. natalense* var. *minor* from Kafirland: *Ecklon & Zeyher, Urtic. 7*; and *Zeyher 3870* from Krakakamma. The variety differed from the type in its elliptical leaves 2.5-4 cm. long, and its very short peduncle. Warburg (1906) made var. *puberula* of *F. natalensis* from Sonder's *U. natalense* and wrote var. *minor* as *Ficus natalensis* var. *minor* as Miquel (1867) had indicated. The pubescence of the first variety, on receptacle and peduncle, has been seen in herbarium specimens of receptacles and has been reported for peduncles of *F. chrysocerasus* and *F. durbanii*, and therefore seems insufficient to differentiate the variety from the typical form of *F. natalensis*. Mildbraed & Burret stated that *F. natalensis* includes var. *puberula* and var. *latifolia* (below), and wrote *U. natalense*  $\beta$  *minor* Sond. at the end of their synonyms. They listed numbers 6 and 7 under examples of the typical form. Hutchinson omitted all Warburg's varieties. Var. *latifolia* from "Cape Colony" was said only to have broad elliptical leaves.

Sim (1909) pictured obovate leaves and a hairy receptacle on a hairy peduncle. The type specimen was Sim 5729 and represented the most common form in Portuguese East Africa, he said. Although his description called the receptacle 1 cm. in diameter the plate showed one 2 cm. in length and width. Hutchinson declared that the type receptacle was glabrous, and placed the



variety under the typical form. Peter, too, considered type and variety the same.

FICUS DEKDEKENA (Miq.) A. Richard, Tent. Fl. Abyssinicae 2:268. 1851.

*Urostigma acrocarpum* (Steud. ex Miq.) Miq. Hook. Lond. Jour. Bot. 6: 557, pl. 22 B. 1847. *Ficus acrocarpa* Steud. ex Miq., *Ibid.* *Nomen nudum*. *F. saligna* Hochst. ex Miq., *Ibid.* 558. *Nomen nudum*. *U. dekdekana* Miq., *Ibid.* 558. *F. tsjela* Hochst. ex Miq., *Ibid.* 558 (Not Roxb.) *Nomen nudum*. *F. dissocarpa* Hochst. ex Richard, Tent. Fl. Abyss. 2: 268. 1851. *Nomen nudum*. *F. acrocarpa* var. *saligna* (Hochst. ex Miq.) Miq. Ann. Mus. Bot. Lugd.-Bat. 3: 288. 1867. *F. dekdekana* var. *pubiceps* Mildbr. & Burr. Engl. Bot. Jahrb. 46: 256. 1911. *F. bequaertii* DeWild, Bull. Soc. Bot. Belg. 52: 200. 1914. *F. dekdekana* var. *angustifolia* A. Peter, Fedde, Repert. 402 106. 1932.

Tree 25-30 m. tall, sometimes starting as an epiphyte; trunk sometimes 2 m. in diameter; air roots present; branches white-barked; twigs pubescent to glabrous, reddish when dry, sometimes exfoliating; stipules deciduous, ovate-lanceolate, subacute, ciliate, red-brown when dry; petioles 2-4.6 cm. long, slender, glabrous; blades stiff-papery, entire, 5-17 x 1.5 cm. (examples: 6 x 3.5, 7 x 2.5, 8 x 4 cm.), oblanceolate or narrow-elliptical, rarely obovate; apex usually with a short thick acumen, rarely obtuse; base narrowed, usually cuneate and acute, rarely obtuse; upper surface glabrous and papillate; under surface glabrous, sometimes with reddish veins; basal veins like secondaries, short and vague, secondaries (laterals) 8-14, usually 8-10 sets, forming a submarginal vein, upper angle at midrib 40° or 50°; usually one strong parallel vein in each intervein, sometimes indenting submarginal vein; several layers of spaces in each intervein; receptacles usually axillary, sometimes clustered on the uppermost twigs, or paired, globose, 6-8 mm. when dry, puberulent or glabrous, smooth or slightly wrinkled, apex a little raised at first, then depressed; no apical bracts visible; basal bracts 3, connate, caducous, ovate, obtuse, puberulent or glabrate; peduncle 2-4.8 mm. long, puberulent or glabrate; flowers with 3 parts of the perianth; male flowers having one stamen with a short filament; female flowers sessile; ovary obovoid; style lateral, slender, equalling ovary; stigma oblong, thickened.

Type: Schimper, Pl. Abyss. sect. I, 220. Sholoda Mts., Ethiopia.

Distribution: Ethiopia, Eritrea, Angola, Gold Coast, Nigeria, Cameroons, Belgian Congo, Sudan, Uganda. This distribution forms a sort of east-west belt across most of Africa, from the Gold Coast to the Red Sea, between 15° north latitude and 10° south latitude.

Among the texts which discuss this species are those mentioned in the above synonymy, and also Miquel, Fic. Afr. (see below), Hutchinson in Prain, Fl. Trop. Africa 62:211-212. 1917, and Lebrun, Esp. Cong. *Ficus* 22: 65. 1934. The New York Botanical Garden has in its herbarium a portion of the type specimen of *F. acrocarpa* Steud., Schimper II, 627, from near Mai Dogale, Abyssinia (Ethiopia), 13 N 1839. The only specimen of *F. dekdekana* (so-called) is Schweinfurth & Riva 790, from Eritrea. This was accepted by Mildbraed & Burret as a valid example, but is almost exactly like no. 2084 of the same collectors, also from Eritrea, which is labeled *F. schimperii* Hochst. ex Richard. *F. schimperii* and both no. 790 and no. 2084 have been cited by

Hutchinson (*in* Prain, *Op cit.*, 6<sup>2</sup>:188. 1916) as synonym and examples of *F. thonningii* Blume. The specimens of leaves obtained in Florida agree well with the descriptions, plates and specimen of *F. acrocarpa*; but have not been used in making the description of *F. dekdekana* in this paper.

#### History of *F. dekdekana*

In Schimper's collection of the plants of Abyssinia, made about 1839, were four sets of specimens which later were united to form the present *F. dekdekana*. A fifth synonym, *F. bequaertii*, has been accepted by Hutchinson and by Lebrun. This evolution of the species was accomplished in several stages.

1. Collection or herbarium names were given to the Schimper specimens as follows: *Schimper sect. I*, 220, *F. tsjela* Hochst.; *Schimper sect. II*, 627, *F. acrocarpa* Steud.; *Schimper sect. II*, 629, *F. dissocarpa* Hochst.; *Schimper sect. II*, 709, *F. saligna* Hochst.

2. Miquel in 1847 and in 1849 (*Fic. Afr.* 145-147, *pl.* 5 C) published descriptions and plates of *Urostigma acrocarpum* and *U. dekdekana*. The former species was based upon *F. acrocarpa* Steud., and was given an unnamed variety made from *F. saligna* Hochst. *U. dekdekana* was derived from *F. tsjela* Hochst., which Miquel spelled *Tsjela*. Here Miquel could not use the specific name given by Hochstetter, because he had already employed it for a different species of *Urostigma*.

3. *U. dekdekana* was transferred to *Ficus* by A. Richard (1851), since *Urostigma* was believed by him, as it is by modern botanists, to be no more than a subgenus of *Ficus*. At the same time Richard cited as synonyms of *F. dekdekana* not only *U. dekdekana* Miq. and *F. tsjela* Hochst., but also *U. acrocarpum* Miq. (which he spelled *macrocarpum*), with *F. acrocarpa* Steud. and *F. saligna* Hochst.; and, in addition, *F. dissocarpa* Hochst. Richard explained this grouping by the remark that the leaves varied, sometimes on the same specimen, from elliptical and acute to obovate and obtuse or acuminate, and that the receptacles differed in size. Most of Richard's synonyms have been accepted or implied by Mildraed & Burret (1911) 46:255, 256; Hutchinson, and Peter (1932) 106. The *acrocarpa* synonyms were omitted by Lebrun, and *F. dissocarpa* by Hutchinson, Peter, and Lebrun. It will be noticed in the synonymy that Miquel (1867) continued to consider *F. acrocarpa* an independent species, and that he finally named var. *saligna*.

4. *F. bequaertii* was added to the synonymy.

#### Validity of Some of the Alleged Synonyms

*U. acrocarpum*. Miquel's distinctions between *U. acrocarpum* and *U. dekdekana* are principally, for the former, wider blades, sub-punctate above; receptacles rarely with a little longer peduncle; perianth with a shorter tube; anthers more obtuse. None of these characters is sufficient in the opinion of authorities to separate the two species. Miquel's original description and plate

of *U. acrocarpum* agree almost exactly with a part of his type specimen in the herbarium of the New York Botanical Garden, except in the case of the receptacle shown in his plate. This is larger than in his description and in the specimen. Schimper's numbers for his four specimens have been accepted for *F. dekdekana* by Hutchinson.

*F. chrysocerasus* Welw. ex Warb., thought by Mildbraed & Burret to be a synonym of *F. dekdekana*, has already been discussed under *F. natalensis*.

*F. bequaertii* was based on a specimen from Elisabethville, Belgian Congo, J. Bequaert 449. The description agrees well with Miquel's of *F. dekdekana*, to which it has been allocated by Hutchinson and Lebrun. De Wildeman thought that *F. bequaertii* might be near *F. petersii* Warb., which he had not seen. But a New York specimen of *F. petersii*, Pole-Evans 3756, has blades with a rounded apex and red-hairy receptacles. Twigs, peduncles, and basal bracts are hairy, also.

In this connection should be mentioned the comparisons of *F. dekdekana* with similar species, made or implied by Mildbraed & Burret, (*Op. cit.*) pp. 250, 255-258, 260, 261.

#### Alleged Varieties

Mildbraed & Burret are the only authors consulted who mention var. *pubiceps*. They stated that it differed from the typical forms of *F. dekdekana* in the long thick hairs of the receptacle and that it was a small variety of the type. The type of the variety was found in Eritrea, Schweinfurth 688, 693. 27 F 1891. Hutchinson does not cite these specimens for *F. dekdekana*.

Peter said of var. *angustifolia* only that the leaves are narrow and long-stalked. Those characters apply also to the plates of Miquel's and to the Florida leaves and so show no difference from typical specimens of the species. The type was from the former German East Africa.

For the reasons indicated in the above paragraphs these varieties, for the present, are included with the type.

#### Comparison of *F. natalensis* with *F. dekdekana*

It is desirable to state the synonymy and to make new descriptions of these species since Florida specimens called *F. volkensii* (a synonym of *F. natalensis*) appear to belong to *F. dekdekana*.

Descriptions of the leaves of these somewhat variable species read much alike. However, the blades of *F. natalensis* are shaped like mandolin picks: broad and rounded or barely acuminate at the apex and narrowed to an acute base at the short petiole, which usually measures 1 cm. The length of the blade is about twice the greatest width. The blades of *F. dekdekana* resemble narrow snowshoes with long tails. The apex is slightly acuminate. The length may be about the same as in *F. natalensis*, although often it is greater; but the width is less in proportion, and the petioles often are 4 or even 6 cm. long. The receptacles are very much the same, although those of *F. dekdekana* may have shorter peduncles.

The ranges of distribution overlap across part of tropical Africa, but *F. natalensis* is found also in the extreme south of the continent, while *F. dekdena* extends north-east into the Sudan, Ethiopia, and Eritrea.

### *Ficus sycomorus* L.

Some years ago there were planted along one of the main avenues in Chapman Field several fig-trees whose round heads, low branching and light-colored scaly bark made them appear like the plane-trees (*Platanus*) of temperate climates. These were sycomores, or sycomore figs. From their title, with a little misspelling, the plane-trees in the United States and the sycamore maple (the sycamore of England) have derived one of their common names.

It is thought that the sycomores originated in Yemen and in Eritrea, on opposite sides of the Red Sea; but that very early they spread to Egypt, other parts of northern Africa, Palestine and neighboring regions, and to some of the islands in the Mediterranean Sea. At present they are found in most parts of Africa, and are grown in other tropical and sub-tropical climates.

This species was known to the Egyptians for thousands of years; for its fruit was pictured by artists of the Fifth Dynasty, and its wood was used for mummy cases, and for carvings such as those of a 5,000-year-old statue now to be seen at Cairo. Its figs were less desirable than those of *Ficus carica*, the "fig-tree" of the Bible; but its large crowns gave such gratefully received shade that the trees needed to be planted on only one side of a road. Leafy branches sometimes were placed in sarcophagi.

The Bible has several references to the sycomore. For example, the prophet Amos (Amos 7:14, Moffatt ed.) stated that he tended these trees. This may have meant not only that he was a gatherer of their fruit, as earlier editions of the Bible have it, but that he also scored the immature figs with a spur on a metal thimble, in order to induce ripening. The Gospel of St. Luke (19:4) relates that Zacchaeus climbed one of these short-trunked trees in order to see Christ as He passed through Jericho. A large specimen at the ancient city of Heliopolis was supposed to have sheltered the Holy Family during their flight into Egypt.

These trees must have gone by many vernacular names, but only a few of them seem to have been preserved in botanical literature. Linnaeus derived *sycomorus* from a Greek name for the species which had been in use from at least the beginning of the Christian era. The first two syllables came from the Greek word for a fig, and the last two formed the Latin name of the mulberry tree. The theory that this species was a mulberry tree which bore figs dates back to Theophrastus, about 300 B.C., and may have been original with him. In his history of plants, as edited by Bodaeus à Stapel and others (1644), book 4, chap. 2 in the parallel Latin version speaks of *Morus aegyptia* as bearing fruit on its trunk, and as seeming to be related to *Ficus cypria*, of Crete. The Greek word used by Theophrastus for *Morus* (mulberry-tree) may be transliterated as *sukaminos* or *sykaminos*, and that for *Ficus* as *sucos* or *sycos*. It is true that in a previous part of his text Theophrastus spoke of

*Ficus aegyptia*. But this tree had pod-like fruits and so could not have been a fig. It may have been *Ceratonia siliqua* L., the carob, or algarroba.

Perhaps Strabo, who visited Egypt between 25 and 20 B.C., was the first to employ the Greek word *sykomoros* in scientific literature. He spoke (*Geographia* bk. 17:2, 4) of the Egyptian *sykaminos* which produced the fruit *sykomoron*. Celsus, born in 25 B.C., seems to have cleared up the confusion concerning these similar terms. In his text *De medicina* (book 3, chap. 18) he mentioned the reported practice of smearing sycamine tears (gum or latex) on the forehead of an insane person to induce sleep, but added that since *sycaminos*, the mulberry, had no tears what were meant were the tears of a tree growing in Egypt and called *sycomoros*. In spite of this statement and a similar one in *De medicina* book 5, chap. 18, the name *sycomorus* as applied to the tree usually has been credited to Dioscorides (about 50 A.D.). Pliny (about 70 A.D.) seems to have been the first to apply *Ficus* and *aegyptia* to the *sycomore*; but *Ficus sycomorus* as a binomial apparently was not used before Linnaeus.

Very many other names were given to the two species mentioned as similar by Theophrastus and eventually recognized by Linnaeus (*Mantissa* 504. 1767) to be one and the same. Some of the pre-Linnean titles were monomials, many were binomials, and a few were polynomials. However, there was little variety. The words Egypt, Crete, Cyprus, and *Sycomorus* appeared again and again; and allusion was made to the ancients and even to Adam. The citation of authors often was incorrect according to modern standards, but probably was intended to supply references rather than sources. A more detailed study of this subject can be made by following up the references listed by Linnaeus, which in turn lead to others covering the majority of the synonyms.

Further discussion, illustrations and references may be found in articles by H. W. Rickett and by me in *Journal of the New York Botanical Garden* 48: 254-262. N 1947.

*Ficus sycomorus* L. Sp. Pl. ed. 1: 1059. 1753.

*F. chanas* Forsk. Fl. Aeg.-Arabica 219. 1775. *F. trachyphylla* Fenzl, Flora 27: 311. 1844. *Nomen nudum*. *Sycomorus antiquorum* Gasp. Ric. Capr. 86. 1845. *S. rigida* Miq. Hook. Lond. Jour. Bot. 7: 110. 1848. *S. trachyphylla* (Fenzl) Miq., *Ibid.* *F. comorensis* Warb. Engl. Bot. Jahrb. 20: 152. 1894. *F. integrifolia* Sim. For. Fl. Port. E. Africa 101. pl. 89. 1909. *F. flavidobarba*, *F. pallidobarba*, *F. ukambensis*, *F. blepharophora* Warb. ex Mildbr. & Burret, Engl. Bot. Jahrb. 46: 192. 1911. *Nomina nuda*.

In Africa a huge tree to 25 m. high and 20 m. in diameter of crown; trunk light-colored, fissured to scaly, branching low; twigs becoming glabrous except at nodes; terminal buds light-colored, hairy; stipules deciduous, hairy on outside; leaves deciduous in southern Florida, mostly located at apex of twigs or on spurs; petioles 2-5 cm. long, mostly about 3 cm. long, red-brown, hairy to glabrous; blades wide-ovate or almost round; margin entire, but sometimes slightly angled; size of blade 5-15 x 4-10 cm. or larger in cultivation; apex obtuse or rounded; base cordate or rounded; upper surface glabrous, dark green, sometimes a little rough; under surface glabrate; midrib continuous to apex of blade; basal veins sometimes more than one pair, upper pair extending far up blade, making with each side of the midrib an angle of about 45°.

lower pair or pairs smaller, each vein making an angle of  $90^\circ$  with the midrib or drooping into the basal lobes; 3.5 (usually 4) prominent sets of lateral veins, each making an angle of about  $40^\circ$  with the midrib and connected with the adjacent laterals by prominent slightly angled transverse veins at almost a right angle; reticulum and checkered background present; receptacles in panicles on leafless twigs from trunk and branches, rarely also axillary, obovoid or obovoid-globose, 2.5 cm. in diameter, green to red, surface dull or slightly hairy, apex rounded, ostiole conspicuous and 5-scaled, apical bracts mostly contained in receptacle, basal bracts 3, tan, pubescent, about 5 mm. long; peduncle 1.5 cm. long, tan, pubescent, sometimes absent; male flowers bearing 2 stamens.

#### Alleged Synonyms and Varieties

*F. sycomorus*, *vera* Forskal frequently is cited as a synonym of *F. sycomorus*. However, it should be rejected, as the comma and the word *vera* obviously were added to differentiate it from *F. sur*, which preceded it in the text and was said to resemble it.

*F. chanas*, from Arabia, was distinguished from *F. sycomorus* by its scabrous leaves. But Mildbraed & Burret (*Op. cit.*) declared that rough leaves were found in wild, although not in cultivated trees; and they added this species to the synonymy of *F. sycomorus*. They included, also, *Sycomorus rigida*, whose blades eventually became rough; and they suggested that *F. comorensis* probably was not different from the sycomore. They were not sure about *F. trachyphylla* because Miquel had not described receptacles. But Miquel's plate of *S. trachyphylla* (Fic. Afr. pl. 1 C. 1849) is so much like his of *S. rigida* (Fic. Afr. pl. 1 B) that it, too, appears to belong to *F. sycomorus*.

*S. antiquorum* was the name given by Gasparrini when he transferred *F. sycomorus* to the new genus *Sycomorus*, of which it was the type.

Warburg differentiated *F. comorensis* (from the Comoro Islands, off the northern coast of Mozambique) from the cultivated *F. sycomorus* by its hairy receptacles and recurved basal bracts. The first character was shown by sycomores at Chapman Field: the second seems unimportant.

*F. integrifolia* Sim (Portuguese East Africa, and Natal) has been accepted as a synonym by Hutchinson (*in* Prain, Fl. Trop. Africa 62:96. 1916). Sim compared it with *F. capensis*, which has the same arrangement of receptacles and the same sort of transverse veining in its blades. But *F. capensis* has leaves which usually are narrower in proportion to their length, and almost always are toothed or at least undulate.

Miquel (Ann. Mus. Bot. Lugd.-Bat. 3:295. 1867) questioned whether *F. cyprina* might be considered a variety of *F. sycomorus*.

Var. *citrina* Schweinfurth & Muschler has been proposed in Muschler, Man. Fl. Egypt 1:249. 1912. *Citrina* was said to have oblong, light-colored receptacles.

The synonymy here presented is principally that of Mildbraed & Burret and of Hutchinson; with the omission of *F. sycomorus vera* Forsk. and the



addition of *F. and S. trachyphylla.* and of *F. comorensis* in the case of Hutchinsonson.

Trees in fruit have been studied at Chapman Field and on the estate of Mrs. Charles T. Simpson in Miami.

### The Vogelii-Nekbudu Group of Ficus

Two large-leaved African fig-trees often seen in Florida resemble each other so closely that they sometimes have been confused, or have been thought to belong to the same species. These trees are *Ficus vogelii* and *Ficus nekbudu* (often called *F. utilis*). This study attempts to differentiate them by references, synonymy, and description, and to express in a key the distinguishing characters of some other species, as yet unreported from Florida, which have been declared similar to them and may turn out to be synonyms or varieties.

*Ficus vogelii* was the first of these species to be named. As it is the most widely distributed and the best described and illustrated its desirability as a standard of comparison is evident. Miquel (Hook. Lond. Jour. Bot. 6:553. 1847) called it *Urostigma vogelii*, thus allocating it to one of the new genera made from *Ficus*, and referring specifically to the German botanist Theodor Vogel, who had collected it in what is now Liberia. However, this did not constitute publication, since Miquel made no description but merely referred to the as yet unpublished *Flora Nigritiana* of Hooker and Benthham. The next year he showed illustrations (*Op. cit.*, 7: pl. 12 A. 1848) of the twig apex, leaf, receptacle, and flowers. In 1849, in the paper usually called *Fici Africani*, he published the first description of *U. vogelii*. This was followed, later in the year, by almost the same text in the long-delayed *Flora Nigritiana*, p. 520. In 1867 Miquel transferred the species to *Ficus*.

Toward the end of the nineteenth century *F. vogelii* became known as part of the source of Lagos (Nigerian) rubber and was reported from other sections of Africa. Miquel's excellent descriptions and plate were corroborated and supplemented by Stapf (*in* H. Johnston, *Liberia* 2:650. pl. 264. 1906), De Wildeman (*Pl. Trop. Cult.* 247-248. 1902, and *Bull. Soc. Bot. Belg.* 52: 233-234. 1914), Milbraed & Burret (*Engl. Bot. Jahrb.* 46:237-238. 1911), Hutchinson (*in* Prain, *Fl. Trop. Africa* 62:179-180. 1916), and others. Plates similar to Miquel's may be seen in Notizb. Koen. Gart. 5:63 (no. 42). pl. 1. 1908, and Engler, *Pfl. Afrikas* 12: pl. 581. 1910, and 31: pl. 29. 1915. Peter (*Fl. Deut. Ostafrika in Fedde, Repert.* 402: 90, 109. 1932) and Lebrun (*Esp. Cong. Ficus* 21, 61. 1934) have supplied valuable keys and references.

Nehrling's notes (*My Gard. Florida* 1:322. 1944) state that he introduced *F. vogelii* into Florida. Specimens under that name have been studied by me at the McKee Jungle Gardens and at Chapman Field. More specimens have been found elsewhere in Florida. Leaves from them have been checked in Washington, at the Arnold Arboretum, and at the New York Botanical Garden. One specimen in New York, *Staudt* 895, was a part of the one cited for *F. vogelii* in Notizblatt (*Op. cit.*)

FICUS VOGELII (Miq.) Miquel, *Ann. Mus. Bot. Lugd.-Bat.* 3:288. 1867.



*Urostigma vogelii* Miq. Fic. Afr. 138. 1849. *F. dob* Warb. ex Mildbraed & Burret, Engl. Bot. Jahrb. 46: 237. 1911. *Nomen nudum*. *F. albivenia* Warb. ex Mildb. & Burret, *Ibid.* 238. 1911. *Nomen nudum*. *F. kaba* De Wildeman, Bull. Soc. Bot. Belg. 52:213. 1914.

Epiphytic strangler or independent tree, becoming 30 m. high; air roots from trunk and lower branches, and prop roots from the base of the trunk sometimes are present; branches gray, bark smooth but scarred when young, becoming scaly and deciduous; terminal buds pointed, reddish-brown, hairy; leaves crowded near the apex of the twigs; petioles 2.5-15 cm. long (mostly 5-10 cm.), reddish-brown, covered with a scurfy epidermis; blades usually somewhat obovate, obovate-lanceolate, or obovate-elliptical, generally 15-30 x 8-15 cm. (examples: 12.5 x 6, 17.5 x 7, 27 x 11, 35 x 19 cm.); thin-leathery, brittle when dry and apt to lose apex and petiole; apex rounded, then abruptly short-thick-obtuse-acuminate; base narrowed and obtuse, or rounded, or rarely sub-cordate; margin entire or slightly undulate; upper surface dark green, bare, dull, darkening when dry; under surface bare or slightly pubescent on the largest veins, lighter green; veins light-colored; midrib continuous to the apex; one distinct pair of basal veins of about the same thickness as the largest laterals but leaving the midrib at a more acute upper angle, with branches depending from it which appear like a second basal pair; 4-6-7 sets of lateral veins (sometimes differing in number in the two vertical halves of the blade, to 6 cm. apart, upper angle about 55° to 50°, straight at first but curving up near the margin and there uniting with the adjacent veins by transverse veinlets (in lower laterals) or by forking (in upper laterals); no such transverse veinlets in the rest of the intervein, but two rows of large reticular spaces which meet in a zigzag line or with a few smaller roundish spaces; checkered background present; receptacles axillary, typically paired or rarely 4-6, almost or quite sessile, subglobose, about 1-1.7 cm. in diameter, yellow or red, with lighter dots when ripe, bare or slightly light-hairy (densely white-hairy in var. *pubicarpa*); ostiole scarcely prominent even when young, open, but showing no apical bracts, 2-lipped; basal bracts 3, silky-pubescent, caducous, leaving a 3-lobed disk 0.7-1.3 cm. in diameter at the rounded base of the receptacle; flowers said to have 3 perianth parts; male flowers almost or quite sessile, with one stamen; female flowers pedicelled, style lateral, stigma thick, shorter than style.

*Type:* Vogel 6. Grand Bassa, Liberia. Jl 1841.

*Distribution:* countries bordering the Gulf of Guinea from Senegal to the Cameroons; Belgian Congo.

*Common names:* West African, Congo, and Memleku Rubber Tree.

*FICUS VOGELII* var. *PUBICARPA* Mildbraed & Burret, Engl. Bot. Jahrb. 46:238. 1911.

*F. incognita* De Wildeman, Bull. Soc. Bot. Belg. 52: 213. 1914.

Leaves like those of the typical form of *F. vogelii*, but receptacle and basal bracts densely white-pubescent.

*Type:* Kersting A 539 and 550. Ap 1908.

*Distribution:* (according to Hutchinson, *Op. cit.*: 180) Senegal, Gold Coast, Togo, Fernando Po, Belgian Congo, Mozambique coast.

#### Synonyms of *F. vogelii*

There is a certain amount of unanimity as to the synonyms cited above. Since few writers have attempted to cover much of the genus *Ficus* in Africa the agreement of any two of them carries weight.

*U. vogelii* has already been mentioned. *F. dob* and *F. albivenia* were names given by Warburg to specimens in the Berlin Herbarium which had been collected in Senegal, and in Liberia and Togo, respectively. Both synonyms were approved also by Hutchinson. *F. kaba* came from near Banzville in the Belgian Congo. De Wildeman stated that it was near *F. albivenia* and belonged to the group of *F. vogelii*. Its description agrees well with *F. vogelii*, and it has been cited as a synonym by Hutchinson and by Lebrun.

#### Varieties of *F. Vogelii*

To the very brief original description of var. *pubicarpa* some characters have been added because of the allocation to it of *F. incognita* De Wild., by Hutchinson and Lebrun. The specific name indicates De Wildeman's ignorance of collection data and his belief that the description was provisional. He said that the species recalled *F. vogelii* and *F. nekbudu*, and also *F. kaba* and *F. albivenia*; and he characterized it in almost the same terms that he applied in the following pages to *F. kaba*, except for the densely velvety receptacles and basal bracts, and the diameter (to 2 cm.) of the receptacles.

An African specimen at the Arnold Arboretum, labeled both *F. dob* and *F. vogelii* var. *pubicarpa*, agrees well with the description of *F. incognita* except that the receptacle measures only 1 cm. in diameter. (However, this is a dry measurement.) There are 6 sets of lateral veins. A specimen of *F. vogelii* in the herbarium of the New York Botanical Garden, obtained from the Harvard Tropical Garden in Cuba, no. 8538, J. G. Jack coll. evidently belongs to this variety. Since it is not certain whether *F. dob* Warb. had a pubescent receptacle that name is placed under *F. vogelii* and not under var. *pubicarpa*.

A second variety, "(?) *kamerunensis*," mentioned by Warburg in *scheda*, was probably identical with *F. quibeba* and *F. cabrae* (see below), according to Mildbraed & Burret (p. 269).

FICUS NEKBUDU Warburg, Ann. Mus. Congo II<sup>1</sup>:6. pl. 4. 1904.

*F. utilis* Sim, For. Fl. Port. E. Africa 100. pl. 91. 1909.

Tree habit, twigs, buds, and petioles resembling those of *F. vogelii*; blades tending to be ovate or elliptical rather than obovate, size and texture like *F. vogelii*, apex less acuminate, base usually not narrowed, surfaces glabrous; basal veins indefinite or like lateral ones in thickness and almost in angle; angle of lateral veins 65°-50°, often 8, 9, or 10 sets, differing in number on opposite sides of midrib, to about 5 cm. apart; other veining like *F. vogelii*; receptacles from 1 to 3 cm. in greatest diameter, subglobose, very hairy, some-

times short-pedunculate, dark red or tan in color; basal bracts densely villous; flowers said to be like *F. vogelii*.

Type: Witterwulghe s. n. Uele, Belgian Congo. 1900.

Distribution: Belgian Congo, Nyasaland, Natal, Lorenzo Marques (Mozambique).

Common names: Kafir Fig-tree, South African Rubber Plant, African Bark-cloth Tree, Zulu Fig-tree. *Nekbudu* is the rendering of a native name.

The above indicates my belief that *F. nekbudu* is different from the typical form of *F. vogelii*, and probably is a distinct species. A résumé of the opinions of others shows no entire agreement on its place. The problem involves the scantiness of the type material, the position of *F. utilis* and other alleged species, and the distribution, common names, and principal use of *F. nekbudu*. Additional specimens may prove it to be a variety of *F. vogelii*.

Warburg described *F. nekbudu* at length and pictured two leaves. But De Wildeman (1914, p. 197) ten years later said that the type material was insufficient, the receptacles had been described from collector's notes, smaller receptacles had been reported, there were in the Congo a large number of related species, the tree might belong to *F. vogelii*, and that perhaps it would be better to discard the species, "which actually becomes a real enigma" (trans.). Mildbraed & Burret made no attempt to differentiate *F. nekbudu* from *F. subcalcarata* and *F. wildemaniana* in their key (pp. 187, 188), but distinguished all three from *F. vogelii* because of more sets of lateral veins (eight or more) and receptacles larger than 12 mm. in diameter. On p. 239 they agreed that *nekbudu* might be *subcalcarata*. Hutchinson (1916, p. 180, and in Thiselton-Dyer, Fl. Capensis 52:535. 1925) declared that the petiole, veins of the blade, flowers, and ostiole were more or less like those of *F. vogelii*, but that the blade apex was rounded. In his key (1916, p. 89) the very slight distinction between *F. vogelii* and *F. nekbudu* was the silky pubescence of the basal bracts of the former as compared with the densely villous bracts of the latter. Lebrun's key (p. 21) used almost the same criterion; but on p. 62 Lebrun declared that no character differentiated those species and that he believed that they and var. *pubicarpa* were the same, although he could not be sure without more material.

Sim's description and plate of *F. utilis* have added to the information concerning *F. nekbudu*, since Hutchinson (1925) stated that Sim's type specimen of *F. utilis* was the same as the type of *F. nekbudu*. The identity of the two has been asserted also by Britton & Wilson (Sci. Surv. P. R. & Virgin Islands 63:342. 1926), Mowry (Florida Agr. Ext. Bull. 95:97. pl. 43. 1938), and Bailey & Bailey (Hortus 2nd, 309. 1941). Mowry's illustration of a leaf of *F. utilis* agrees well with the plates of Warburg and Sim. But Sim (1927) 386 seems to consider *F. utilis* a synonym of *F. vogelii*.

The New York Botanical Garden's Exploration of Cuba, no. 9411, contains leaves of *F. nekbudu*. A tree labeled *F. utilis* at the McKee Jungle Gardens has furnished leaves and receptacles which have been compared with a tree of *F. vogelii* in the same garden. I was assured there that the two

species were different. However, some specimens obtained from Florida nurseries and on private property or along streets were *vogelii*, even although labeled *utilis*.

The common names for *F. vogelii* and *F. nekbudu* express decided differences in the distribution and principal economic value of the two species. It is true that both are found in the Belgian Congo, but except for that location the former is a West African and the latter an East or Southeast African tree. Hutchinson's location of var. *pubicarpa* in Mozambique apparently is not confirmed by other writers.

**Species Which May Prove to Be Related to *F. Vogelii* or *F. nekbudu***

Warburg, that prolific species-maker, mentioned *quibeba*, *subcalcarata*, *vohsenii*, *vestito-bracteata*, and *cabrae* as bearing some resemblance to *F. vogelii*; and *holstii*, *bubu*, and *nekbudu* as comparable with *verrucocarpa cabrae*, and "*calcarata*" (*subcalcarata*). Mildbraed & Burret, Hutchinson, and others have recorded similarities and made some synonyms from these and other species. Although writers do not always agree, and although specimens of most of these species seem limited in quantity and quality still there are sufficient descriptions to form the basis for the discussion and the very imperfect key which follow.

These species have in common: a large tree habit; fairly thick petioles; large leathery ovate (sometimes obovate) or elliptical blades with an obtuse apex or a short acumen, a base without overlapping folds, an entire margin, a glabrous upper surface, few and distant lateral nerves, and a reticulation such as has been described for *F. vogelii*. The receptacles are axillary, usually paired, almost globose, almost or quite sessile, with a 2-lipped ostiole without visible bracts, and with two or three basal bracts. The male flowers have one stamen. Variations may occur to a slight degree in the same tree.

Certain of the characters which have been said to distinguish a species from others may not be unique after all. For example: the pubescence of the under surface of a blade may disappear with age, reports of the size of a receptacle may vary as the fig is fresh or dried, and the shape of the fig may change as it matures. It is suspected that warty surface and dilated or spurred shape of the receptacle are not constant characters. Only after more examples of these species are reported can their true position be determined.

Two species, *F. vestito-bracteata* and *F. akaie*, were said by De Wildeman (1914, pp. 231, 198) to bear the native name *Negbudu*. Of these the former had been declared by its author, Warburg (Engl. Bot. Jahrb. 20:159. 1894), to be very near *F. vogelii* in the shape and veining of the leaves, but different from it in its bare leaves, yellow-hairy basal bracts, and receptacles 2-2.5 cm. wide and 2 cm. long. It resembles *F. nekbudu* in its glabrous blades with 7-10 sets of lateral veins and its large receptacles, and, perhaps, in its hairy bracts, although these apparently are slightly different. Mildbraed & Burret (p. 238) thought that *F. vestito-bracteata* was a variety of *F. subcalcarata* Warb. & Schweinfurth (Engl. Bot. Jahrb. 20:155. 1894) because it differed, they thought, only in its long-hairy bracts. But the latter is supposed to have a receptacle which is dilated or spurred and sometimes warty. Both Hutchinson

and Lebrun consider *vestito-bracteata* an independent species. It has been reported from both East and West Africa and from the Belgian Congo. In the last region it is called also *Akaie*.

*F. akaie* De Wildeman (1914, p. 198) seems quite different from both *F. vogelii* and *F. nekbudu*, but rather like *F. subcalcarata*. The type was from the same district in the Belgian Congo in which *F. nekbudu* was discovered.

Of the remaining species of this group *F. monbutensis* Warb. has been allocated to *F. afzelii* var. *caillei* (A. Chev. ex Mildb. & Burr.) M. F. Barrett (*F. eriobotryoides* var. *caillei*), *F. verrucocarpa* Warb. to *F. quibeba* Welw. ex Ficalho, and *F. vohsenii* Warb. in part to *F. bubu* Warb. *F. wildemaniana* Warb. is distinct because of its very large blades and disproportionately small petioles, and receptacles 3-4.5 cm. in diameter. *F. bubu* also has very large receptacles. *F. holstii* Warb. differs from the others in a rounded apex plus a narrowed base in the blade. *F. cabrae* Warb. was based on only two leaves, according to Hutchinson, and so can not be identified. *F. quibeba* is a gray-hairy, warty-receptacled form rather like var. *pubicarpa*. *F. pseudovogelii* A. Chev. has been said by Hutchinson (1916, p. 178) to have habit and leaves like *F. vogelii*, although its receptacles measure 2.5 cm. in diameter. It is reported from the French Congo and Lagos.

The key which follows may bring out additional points, obtained from descriptions and, in the case of *F. wildemaniana*, from an herbarium specimen.

#### KEY TO CERTAIN SPECIES IN THE VOGELII-NEKBUDU GROUP

1. Receptacles often more than 3 cm. in diameter.
  2. Blades usually more than 24 cm. long, generally with more than 10 sets of lateral veins; receptacles sessile ..... *F. wildemaniana*
  2. Blades not more than 24 cm. long, generally with 6-10 sets of lateral veins; receptacles short-peduncled ..... (*F. vohsenii* in part), *F. bubu*
1. Receptacles not more than 3 cm. in diameter.
  2. Receptacles almost or quite glabrous at maturity; sessile.
    3. Receptacles glabrous, sometimes more or less warty; basal bracts glabrous; blades with 7 or more sets of lateral veins.
      4. Receptacles not more than 2 cm. in diameter, not spurred.
        5. Receptacles obovoid; basal bracts separate; blade apex rounded .... *F. holstii*
        5. Receptacles globose; basal bracts forming a disk; blade apex oblong-cuneate ..... *F. akaie*
      4. Receptacles 2-2.5 cm. in diameter, dilated or spurred at base; blade apex short-acuminate ..... *F. subcalcarata*
    3. Receptacles glabrescent, not warty; basal bracts hairy.
      4. Blades with 7-10 sets of lateral veins; receptacles 2-2.5 cm. in diameter ..... *F. vestito-bracteata*
      4. Blades with 5-8 sets of veins; receptacles less than 2 cm. in diameter ..... (*F. kaba*) *F. vogelii*
  2. Receptacles decidedly hairy at maturity.
    3. Receptacles warty, gray-hairy, to 2 cm. in diameter ..... (*F. verrucocarpa*) *F. quibeba*
    3. Receptacles not warty.
      4. Receptacles white-pubescent, to 2 cm. in diameter ..... (*F. incognita*) *F. vogelii* var. *pubicarpa*
      4. Receptacles tan or red, pubescent, often more than 2 cm. in diameter.....

### Summary

The name *Ficus afzelii* G. Don ex Loudon has been approved instead of the frequently used *F. eriotryoides* Kunth & Bouché. This has caused the making of two new combinations by the transference of varieties of the latter species to *F. afzelii*.

The description of *F. bussei* has been much enlarged.

The synonymy of *F. capensis* has been increased by the addition of several forms previously thought to be varieties. A key has been made to the synonyms of this species, which, with the discussion, shows a spiral relationship rather than varieties.

The correct name, *F. lyrata* Warb., has been emphasized instead of the commonly used *F. pandurata*.

Distinctions have been made between *F. natalensis* Hochst. ex Krauss and *F. dekdekana* (Miq.) A. Richard, and *F. volkensii* Warb. has been shown to be a part of the synonymy of the former species.

A brief discussion of the historical background of *F. sycomorus* L. has been made, in addition to the usual synonymy, etc.

*F. vogelii* (Miq.) Miq. has been distinguished from *F. nekbudu* Warb. Other species which have been suggested as related to them have been discussed and a key made.

Among these species *F. lyrata* is easily identified by its fiddle-shaped leaf, *F. bussei* by the overlapping basal folds of the blade, and *F. afzelii* by its obovate or oblanceolate blade without overlapping folds. These are very large-leaved forms. *F. capensis* usually has blades with a toothed or sinuate margin. This species and *F. sycomorus* bear figs in bunches on the tree trunk and large branches. *F. sycomorus* has roundish blades. *F. vogelii* and *F. nekbudu* have rather large obovate or elliptical blades. Both are fairly common in Florida. *Natalensis* and *dekdekana* are small leaved forms, rather obovate and not very characteristic. I have not seen the former in Florida.

# Studies in the Comparative Anatomy of the Ericales

## I. Ericaceae—Subfamily Rhododendroideae

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### Introduction

The systematic position of the Ericaceae has long posed a vexing problem for the taxonomist. It is a fairly large family, including at least 1300 species in some 60 or more genera, whose distribution is world-wide with areas of concentration in temperate regions and in high mountainous areas of the tropics. Its members are characteristically deciduous or evergreen trees, shrubs or perennial herbs whose usually pentamerous or tetramerous flowers are either regular or irregular, epigynous or hypogynous, polypetalous or sympetalous. Carpellary number varies from 20 to 1 and there are normally as many or twice as many stamens as there are corolla lobes. The fruit is a loculicidal or septicidal capsule, a berry or a drupe. Usually many seeds are produced in each fruit, although sometimes only one is formed.

With so many variable characteristics this group proves difficult to locate conveniently in any of the great systems of classification. Drude (1889) places the family in the Order Ericales of the Sub-class Metachlamydeae, although the family includes several polypetalous forms. Bessey (1915) likewise characterizes the family as sympetalous, and in addition considers the order and family to be typically actinomorphic and hypogynous, although there are several exceptions to the former and numerous exceptions to the latter. Hutchinson (1926) considers the entire order to be typically sympetalous and so places it in his scheme, taking due note of the occurrence of epigyny within the order. However, he assigns the epigynous forms to the separate family Vacciniaceae. This treatment is favored by many modern taxonomists and acceptance of the Vacciniaceae as a distinct family is now quite commonplace.

Very little anatomical evidence has hitherto been available to taxonomists to assist them in evaluating this family. Solereder (1908) describes the vessel perforation structure of several genera and the tertiary thickening of the vessels of *Arctostaphylos*, *Arbutus*, *Rhododendron*, etc., but no exhaustive anatomical study has yet been made on more than a few genera. Copeland (1943), in his revision of the Rhododendroideae, contributes much to our knowledge of floral and leaf anatomy but he has left the wood anatomy of the members of that group virtually unexplored. Anatomical evidence has proven of considerable worth in establishing relationships of other puzzling families, as exemplified by the work of Tippe (1938) on the Moraceae, Garratt (1933) on the Myristicaceae and the Monimiaceae (1934), and that of many others. It was thought to undertake a similar study, therefore, of the woods of the Ericaceae, to place at the disposal of anatomists and taxonomists an additional fund of data which might cast light on relationships of genera



within the family and on the relationship of the Ericaceae to other groups suspected of being allied with it.

The classification of Engler and Prantl was decided upon as the basic system of classification to be used for several reasons, although the obsolescence of this system in a number of respects is fully realized.

First, of all modern systems of classification, that of Drude is perhaps most complete in treating this family, inasmuch as it is carried as far as genera and quite often includes specific treatments as well. This is of inestimable value in such a work as this wherein an attempt is made to establish relationships between genera and generic groups which transcend the limits of regional or even continental taxonomic works.

Second, the Englerian system is valuable to the anatomist, paradoxically enough, because it is an old and conservative one. The primary aim of the anatomist is to provide new and significant material for use in conjunction with traditional morphological data to establish relationships based upon a more complete knowledge of the plants than is afforded by a consideration of gross morphological features alone. Therefore it is wise for him to use as a point of departure a sound, conservative classification system that is widely known and recognized. His investigations may then serve to strengthen some existing, more recent taxonomic system or may indeed suggest another, sounder system.

Third, the writer feels there is much worth in a system which keeps to a minimum, consistent with sound taxonomic principles, the number of classification units. Thus the adoption of the Englerian system which groups together in the Ericaceae both polypetalous and sympetalous, hypogynous and epigynous forms, allows comparison within the confines of a large, related unit. This enhances the possibility of tracing the transition from, for example, polypetaly to sympetaly. If such apparently little related characteristics can be shown actually to be rather closely related, then revisions of other groups with similar characteristics may be made subsequently.

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#### Materials and Methods

Collections consisting of portions of stem evidencing secondary wood growth were made by the writer in the Herbarium of the University of North Carolina, the Herbarium of the New York Botanical Garden, and in the United States National Herbarium. In addition many specimens were supplied by curators of herbaria at the Chicago Natural History Museum and

the University of California, and by D. W. H. Camp of the New York Botanical Garden from his private collections.

Sections and macerations were made of stem regions with secondary wood tissues. Sectioning of the previously boiled stem blocks was at  $10\text{--}15\mu$ . Preparation of these sections was by traditional anatomical techniques.

Jeffrey's maceration technique (Chamberlain, 1932) was the basic one employed. The prescribed method of allowing full strength maceration fluid to act upon wood material for about 24 hours produced excellent dissociation of wood elements in specimens that were old and quite woody. However, it was found that if younger and less woody specimens were treated according to this schedule almost total disintegration of wood elements resulted. To meet this condition Jeffrey's maceration fluid must be diluted with water to one-half or one-quarter strength and allowed to act on the tissues for from 3 to 12 hours only. This must be followed by rapid removal of the maceration fluid by repeated washings with water. A centrifuge will greatly accelerate this process.

Usually macerated wood elements are stored in vials of glycerin-alcohol-water and a small quantity of material must be removed and mounted on a slide each time one wishes to study it. The following method by means of which permanently mounted and stained macerated material may be prepared, was evolved. A slide is prepared with Haupt's gelatin fixative. A small amount of water (3-4 drops) containing an abundance of macerated wood elements suspended within it is then mixed with an equal quantity of 8% formalin. A smear is made of this suspension on the slide which is then placed on a slide warmer to dry. Upon drying, the wood elements are firmly affixed to the slide and consequently it may be handled in Coplin jars as is any other slide. This method allows critical staining of the wood elements and effects a considerable saving in time and patience when contrasted with the usual procedure of handling macerated material in bulk.

Numerous investigators have established basic dicta for the comparative study of secondary wood elements. Gilbert (1940) concluded that the evolutionary development of secondary wood proceeds from a primitive diffuse porous arrangement of vessel elements in which annual rings may be scarcely recognized, to a ring porous condition in which the alternate arrangement of vessel areas with wood fiber regions sharply delimits annual rings.

Kribs (1935) found the structure of the medullary rays of various woods differing considerably. He recognized six basic types of medullary ray structure and his terminology is followed in this series of papers.

Frost, in three highly significant papers (1930, 1930a, 1931) describes in detail the phylogenetic development of the vessel element in the secondary wood of dicotyledons. His conclusions, now classed among the important tenets of wood anatomical research, are briefly summarized here:

1. Primitive vessel segments are characterized by:
  - (a) great average length;
  - (b) small cross-sectional diameter;
  - (c) angularity of outline in cross-section;
  - (d) evenly thickened walls;
  - (e) thin walls;

- (f) absence of a distinct end wall;
  - (g) end wall perforations that are scalariform with many bars and small apertures;
  - (h) lateral wall pits that are scalariform and fully bordered;
  - (i) absence of tertiary thickening of the vessel segment wall.
2. Phylogenetic development of the vessel segments is manifested in:
- ✓ (a) reduction in average length;
  - ✓ (b) increase in cross-sectional diameter;
  - ✓ (c) change from angular to round cross-sectional outline;
  - ✓ (d) uneven thickening of walls;
  - ✓ (e) acquisition of thick walls;
  - ✓ (f) change in end wall from a highly inclined position to a transverse position.
  - ✓ (g) change from a scalariform to porous end wall perforation by loss of bars and widening of apertures;
  - ✓ (h) specialization of scalariform lateral wall pits to produce first, transitional elongate-elliptic opposite pits, second, round opposite pits, and finally, highly specialized alternate round intervacular pits;
  - ✓ (i) gradual loss of borders on lateral wall pits;
  - ✓ (j) introduction of tertiary thickening in vessel elements of secondary wood.

These basic conclusions are used as criteria in the comparative study of the woods of the Ericaceae. It is recognized that any one group of plants cannot be expected to exhibit a gradual transition from most primitive to most advanced conditions in each of the above outlined phylogenetic lines. However, a large and diversified group such as the Ericaceae should show considerable variation in wood anatomical characters between its most primitive and its most advanced members, although its most primitive members need not possess, for instance, the most primitive known vessel structure, nor need its most advanced member possess the most advanced vessel structure known. Rather is it necessary to determine the relative primitiveness of its most primitive member, the relative advancement of its most advanced member and from this to determine the upper and lower limits of the evolutionary progression within the family itself. Once the limits are established then the relative degree of wood anatomical advancement of any species may be determined. Thus it was found that, whereas vessel wall outline ranges all the way from the most primitive angular condition to the most advanced round condition, inclination of the vessel end wall angle has progressed only from the primitive highly inclined condition to a moderately advanced condition exhibited by an approximate 45° angularity.

With all these considerations in mind a set of wood anatomical characteristics showing significant and diagnostic variations between the woods of the various genera was established. These may be summarized as follows:

1. WOOD TYPE.—Three types are recognized: a primitive diffuse porous, an intermediate semi-ring porous, and an advanced ring porous type.
2. VESSEL WALL THICKNESS.—Thin vessel walls are primitive and thick walls are derived.
3. VESSEL WALL EVENNESS.—In this characteristic walls of even thickness are primitive and unevenly thickened walls are advanced.
4. VESSEL OUTLINE.—Variation within the Ericaceae is from the primitive angular outline to the derived round outline condition.

## 5. VESSEL DIMENSIONS.

- (a) *Average vessel diameter.* This dimension was computed on the basis of diameter measurements of 50-100 secondary wood vessels in both macerations and cross-sectioned material of each species studied. This represents the average maximum diameter of all vessels measured.
  - (b) *Average vessel length.* Chalk and Chattaway (1934) have shown that overall vessel member length, including vessel "tails", most closely approximates the length of the vessel element's cambial initial, and therefore is a more significant measurement than length of the vessel body alone. This method was used in measuring vessel element length and the average vessel length was computed from 50-100 such measurements of macerated material for each species studied.
  - (c) *Maximum and minimum vessel measurements.* These are the maximum and minimum single readings recorded for any species within a genus and thus represent the extreme range of vessel diameter and length measurements in that genus.
  - (d) *Ratio of average vessel diameter to average vessel length.* This criterion is one proposed here for the first time. It is established to facilitate comparison between vessel dimensions of genera recognized to be closely related. If two such genera have approximately equal average vessel diameters but their diameter to length ratios are 1:10 and 1:15, the genus of 1:10 ratio is considered to be more advanced, all other considerations of vessel structure being equal. This appears to be a valuable diagnostic character in treating generic groups whose anatomical features suggest a common ancestor, perhaps extinct, from which they have evolved along separate, almost parallel lines. A comparison of their vessel diameter to length ratios therefore establishes the relative level of advancement attained by each since the divergence of their several phylogenetic lines. Also it may be used in conjunction with other anatomical data to establish the degree of advancement that has been achieved by one genus in the course of its known development from another genus. It is not here suggested that the use of vessel diameter to length ratios necessarily will prove of value in establishing relationships between widely separated forms.
6. VESSEL END WALL ANGLE.—Since end wall angle variation in the family lies within the approximate range of  $15^{\circ}$  to  $45^{\circ}$ , the point of division is set at  $30^{\circ}$ . End wall angles between  $15^{\circ}$  and  $30^{\circ}$  are considered primitive and those between  $30^{\circ}$  and  $45^{\circ}$  are considered more advanced.
7. VESSEL PERFORATION PLATE.—Wide variation in end wall perforation condition occurs in the family, ranging from strictly scalariform to strictly porous. The average number of bars comprising the scalariform perforation ranges from 1 in some genera to 16 or more in others. An arbitrary point of division was set at 8 bars to separate the primitive

many-barred scalariform and the more advanced few-barred scalariform observations of vessel perforation plates were made. This data is barred scalariform condition, an intermediate few-barred scalariform condition and an advanced porous condition. For each species 40-60 conditions. Three basic types are thus established: a primitive many-recorded in the tables as the percentage of observed vessel cells with perforation plates falling in the above established categories. In treating homogeneous type and that either Heterogeneous Type II or Type III rays genera in which two or more species were studied the generic percentage tabulated is the average of the specific percentages in that category. In addition the average number of bars comprising the scalariform plates (disregarding entirely porous plates where they occur) has been computed and tabulated for each genus and species.

8. VESSEL SIDE WALL PITS.—Structural types present in the family range from primitive scalariform pits, through transitional elongate-elliptic opposite pits to advanced round opposite pits.
9. WOOD PARENCHYMA PITTING.—As would be expected the same structural types of pits are found in the wood parenchyma cell walls as are found in the vessel side walls and there is a marked correlation between the pitting of these two cell types in a given genus or species.
10. TERTIARY THICKENING OF THE VESSEL WALL.—Tertiary thickening is absent in the primitive state and present in the derived condition. Type of thickening present is noted in each case in the tables and in the discussion.
11. MEDULLARY RAY TYPE.—All medullary rays observed thus far have been of the Heterogeneous type as defined by Kribs (1935). He holds that Heterogeneous Type I rays are the most primitive of the Heterogeneous may develop directly from Type I or that Heterogeneous Type III rays may develop from Type II.

A careful weighing and balancing of evidence gained from investigation of wood anatomy in accordance with the above criteria should well establish the overall level of phylogenetic development attained by any given genus with respect to its wood anatomical characteristics. Likewise the application of these criteria to a group of related genera will establish the level of advancement reached by that group. Comparison between genera and generic groups can then be made on the basis of wood anatomical data. Such comparative anatomical data may be used valuably in conjunction with data already known from study of their morphology. Together, anatomical and morphological data should provide a clearer understanding of the inter-relationships within any given group of plants than either set of observations alone would yield.

The writer has attempted such an approach in this study of the Ericaceae. Although this is primarily an investigation of the microscopic anatomy of the woods of the Ericaceae, the data derived from it is designed to be integrated with the fund of available morphological data, not to supersede it. In the discussion of generic, tribal and sub-familial relationships the conscientious attempt is made to assign weight to carpellary condition, floral structure, growth habit

# TRIBE I BEJARIEAE

Fig. 1

	WOOD TYPE	VESSEL OUTLINE	VESSEL WALL			VESSEL DIMENSIONS			VESSEL PERFORATION				VESSEL SIDE WALL PITS		WOOD PARENCHYMA PITS	3 <sup>rd</sup> THICK.	MED. RAY TYPE		
			THIN	THICK	UNEVEN	DIAMETER	LENGTH	RATIO	% SCALAR. 9-10 BARS	% SCALAR. 8-9 BARS	% POROUS	AVERAGE NO. BARS SCAL.	SCALARIFORM	ELONGATE - ELLIPTIC			ABSENT	PRESENT	MED. I
BEJARIA		ANGULAR				31.0	399.0	1:13	0	61	39	4.1							MED. II

# TRIBE II CLADOTHAMNEAE

Fig. 2

	WOOD TYPE	VESSEL OUTLINE	VESSEL WALL			VESSEL DIMENSIONS			VESSEL PERFORATION				VESSEL SIDE WALL PITS		WOOD PARENCHYMA PITS	3 <sup>rd</sup> THICK.	MED. RAY TYPE		
			THIN	THICK	UNEVEN	DIAMETER	LENGTH	RATIO	% SCALAR. 9-10 BARS	% SCALAR. 8-9 BARS	% POROUS	AVERAGE NO. BARS SCAL.	SCALARIFORM	ELONGATE - ELLIPTIC			ABSENT	PRESENT	MED. I
CLADOTHAMNUS						19.7	304.4	1:15	8	64	28	5.5							MED. II
ELLIOTIA						30.8	368.2	1:12	7	49	44	6.2							MED. II
TRIPETALEIA						24.2	327.1	1:14	35	20	45	9.2							MED. II

# TRIBE III PHYLLODOCEAE

Fig. 3

	WOOD TYPE	VESSEL OUTLINE	VESSEL WALL			VESSEL DIMENSIONS			VESSEL PERFORATION				VESSEL SIDE WALL PITS		WOOD PARENCHYMA PITS	3 <sup>rd</sup> THICK.	MED. RAY TYPE		
			THIN	THICK	UNEVEN	DIAMETER	LENGTH	RATIO	% SCALAR. 9-10 BARS	% SCALAR. 8-9 BARS	% POROUS	AVERAGE NO. BARS SCAL.	SCALARIFORM	ELONGATE - ELLIPTIC			ABSENT	PRESENT	MED. I
LEDOTHAMNUS		A				21.6	409.9	1:19	89	11	0	12.1							MED. II
LEIOPHYLLUM		N				23.3	346.5	1:15	62	38	0	9.4							MED. II
LOISELEURIA		G				24.6	293.8	1:12	53	47	0	8.5							MED. II
DIPLARCHE		U				18.7	280.3	1:15	100	0	0	8.2							MED. II
PHYLLODOCE		L				20.1	275.7	1:14	79	21	0	11.1							MED. II
BRYANTHUS		A				19.0	226.6	1:12	80	20	0	10.8							MED. II
RHODOTHAMNUS		R				20.1	356.1	1:17	100	0	0	18.3							MED. II
KALMIA						21.9	357.7	1:16	98	2	0	16.2							MED. II

# TRIBE IV DABOECIEAE

Fig. 4

	WOOD TYPE	VESSEL OUTLINE	VESSEL WALL			VESSEL DIMENSIONS			VESSEL PERFORATION				VESSEL SIDE WALL PITS		WOOD PARENCHYMA PITS	3 <sup>rd</sup> THICK.	MED. RAY TYPE		
			THIN	THICK	UNEVEN	DIAMETER	LENGTH	RATIO	% SCALAR. 9-10 BARS	% SCALAR. 8-9 BARS	% POROUS	AVERAGE NO. BARS SCAL.	SCALARIFORM	ELONGATE - ELLIPTIC			ABSENT	PRESENT	MED. I
DABOECIA		ANGULAR				21.7	264.1	1:12	0	0	100	-							MED. II

# TRIBE V RHODODENDREAE

Fig. 5

	WOOD TYPE	VESSEL OUTLINE	VESSEL WALL			VESSEL DIMENSIONS			VESSEL PERFORATION				VESSEL SIDE WALL PITS		WOOD PARENCHYMA PITS	3 <sup>rd</sup> THICK.	MED. RAY TYPE		
			THIN	THICK	UNEVEN	DIAMETER	LENGTH	RATIO	% SCALAR. 9-10 BARS	% SCALAR. 8-9 BARS	% POROUS	AVERAGE NO. BARS SCAL.	SCALARIFORM	ELONGATE - ELLIPTIC			ABSENT	PRESENT	MED. I
LEDUM		A				20.7	320.2	1:15	93	7	0	12.5							MED. II
TSUSIOPHYLLUM		N				19.0	294.5	1:16	90	10	0	12.0							MED. II
RHODODENDRON		G				20.7	386.6	1:19	92	8	0	13.9							MED. II
AZALEA		U				21.7	340.8	1:16	14	39	47	7.0							MED. II
MENZIESIA		L				24.5	302.3	1:12	32	60	8	6.9							MED. II
AZALEASTRUM		R				23.7	256.3	1:11	0	31	69	3.2							MED. II

Figs. 1-5.—Summary of significant wood anatomical data for genera of the five tribes of the Rhododendroideae



and other morphological characteristics as well as to details of wood anatomy, in the proportion of their considered importance. The fact that conservative taxonomic treatments of the family are not herein radically altered bespeaks not only the fact that undue and disproportionate stress has not been placed on anatomical evidence, but also that traditional taxonomic methods and practices are basically sound.

### Discussion

The Ericaceae as generally defined is a large and rather heterogeneous family. Its members may be characterized as shrubs, trees and perennial herbs of warm and cold-temperate regions and high mountains of the tropics. Flowers are regular or irregular, hypogynous or epigynous (if the Vacciniaceae are included), bisexual, 5-merous or 4-merous, with polypetalous or sympetalous corollas. Stamens are usually as many as or twice as many as the number of corolla segments. Anthers are two celled, with or without appendages, opening by pores, slits or chinks. The ovary is of 1 to 20 cells. The fruit is a capsule, berry or drupe with usually small seeds. Anatomically this family may be characterized generally by: (1) absence of ring-porous wood. (2) vessel end wall angle less than  $45^\circ$ , (3) typically half-bordered vessel side wall pits and (4) absence of Homogeneous type medullary rays. Variation in other anatomical characteristics is considerable and may be used as diagnostic characteristics within the family.

It seems desirable to postpone further general discussion of the family as it is now constituted until after each of its subfamilies has been treated in detail. Final discussion of the family as a whole will therefore appear in a later paper.

The first paper of the series is devoted to the subfamily Rhododendroideae—a taxonomic unit that has been recognized by that name since 1888.

### Subfamily RHODODENDROIDEAE Breitfeld.

Corolla of 3-8 free or fused petals, deciduous. Stamens 4-14. Anthers without horns or awns. Ovary superior, of 2-20 cells. Fruit a septicidally dehiscent capsule. Wood typically diffuse porous. Vessels angular in outline, usually with thin, even walls. Vessel end wall angles averaging less than  $30^\circ$ . Vessel perforation plates scalariform to porous. Tertiary thickening of the vessel wall absent or present in small amount, appearing as a thin, delicate, spiral-reticulum on the long tails of the vessel elements. Medullary rays Heterogeneous Type I, IIA or IIB.

Drude recognized seventeen genera in his survey of the group. For the most part Copeland follows Drude. However, he reduces *Tripetaleia* to *Elliottia*, as did Bentham and Hooker, and divides *Rhododendron* into five genera. Thus Copeland recognizes a total of twenty genera. Here *Tripetaleia* is considered a genus, *Hymenanthes* is returned to *Rhododendron*, and adequate stem material of *Therorhodon* was not available for study. Therefore this study is based on nineteen genera, as follows: *Bejaria* Mutis, *Cladothamnus* Bongard, *Elliottia* Muhlenberg, *Tripetaleia* Siebold & Zuccarini, *Ledothamnus* Meissner, *Leiophyllum* Persoon, *Loiseleuria* Desvaux, *Diplarche*



Hooker f. et Thomson, *Phyllodoce* Salisbury, *Bryanthus* D. Don, *Rhodothamnus* Reichenbach, *Kalmia* L., *Daboecia* D. Don, *Ledum* L., *Tsusiophyllum* Maximowicz, *Rhododendron* L., *Azalea* L., *Menziesia* Smith and *Azaleastrum* (Planchon) Rydberg.

This rather diversified group is unquestionably the most primitive of the subfamilies. Its relative primitiveness is established by the large number of carpels, petals and stamens of some genera, the presence of several polypetalous genera, and by the primitive nature of wood structure. Nevertheless, some genera have evolved along certain lines to a relatively high level of advancement, as witnessed by the appearance of fused petals, vessels with porous perforation plates, ovaries with as few as two cells and tertiary thickening of the vessel walls.

It appears quite probable that development in this subfamily has proceeded simultaneously along several parallel evolutionary lines. Drude has already recognized the existence of three groups. The present anatomical study corroborates in large measure the validity of Drude's classification in that his three tribes are retained with virtually their original generic complements. Some changes have been necessary, principally the recognition of two additional small tribes and the rearrangement of certain genera between and within the tribes.

#### Tribe I. BEJARIEAE Copeland

##### Figs. 1, 6

Corolla of 5-8, usually 7, free petals. Stamens usually twice the number of petals. Anthers opening by terminal pores. Ovary normally 7 celled, hypogynous, developing into a 7 grooved capsule which opens at the tip. Leaves firm and leathery. Wood diffuse porous. Vessels angular in outline with thin and even walls. Vessel perforation transitional between scalariform with less than eight bars and porous. Vessel side wall with half-bordered pits, scalariform to round opposite. Tertiary thickening of vessel walls present. Medullary rays transitional between Heterogeneous Type I and Heterogeneous Type IIA.

The Bejarieae, composed of one genus, is probably the primitive tribe of the subfamily. This conclusion is based on the numerous petals, stamens and carpels typical of its floral structure. However this primitiveness is manifested more in morphology than in anatomy, since anatomically *Bejaria* is more advanced than several of the lower genera of other tribes. As figure 1 shows, the 1:13 vessel diameter to length ratio, the absence of many-barred scalariform perforations, and the transitional stage in medullary ray development of *Bejaria* stamps it as rather highly evolved anatomically when compared with other genera of the subfamily with markedly more advanced morphological characteristics. This immediately suggests that *Bejaria* may have descended from an entirely different ancestor than the one that gave rise to the remaining tribal groups. Assuming that morphological and anatomical development proceeded at the same rate, which of course need not necessarily have occurred, *Bejaria's* ancestor would have been more advanced anatomically and less advanced morphologically than was the ancestor of the other tribes. If, however, *Bejaria* did in fact descend from an ancestor common to the other tribes,

then anatomical development must have taken place at a faster pace than morphological development.

Not only has *Bejaria* evolved along characteristically different lines from the other tribes, as indicated by conditions of perforation plate structure, vessel side wall and wood parenchyma pitting, and medullary ray type, but the genus itself evidences much anatomical variation in its species. The following table lists these variable characteristics.

#### BEJARIA Mutis

Tabulation of anatomical characteristics varying between the species.

*B. aestuans* Mutis & Sleumer (NY—Pennell & Killip 7412)<sup>1</sup>. *B. ledifolia* HBK (NY—Pittier 6228). *B. glauca* H. & B. (NY—Sandwith 1369; NY—Schultes 677). *B. discolor* Benth. (NY—Mexia 9276). *B. cubensis* Griseb. (NY—Palmer & Riley 205).

	<i>B. aestuans</i>	<i>B. ledifolia</i>	<i>B. glauca</i>	<i>B. discolor</i>	<i>B. cubensis</i>
Vessel diameter					
Maximum .....	45.4 $\mu$	35.7 $\mu$	43.8 $\mu$	50.3 $\mu$	45.4 $\mu$
Minimum .....	21.1 $\mu$	16.2 $\mu$	13.0 $\mu$	21.1 $\mu$	19.5 $\mu$
Average .....	33.3 $\mu$	25.1 $\mu$	25.7 $\mu$	36.8 $\mu$	34.1 $\mu$
Vessel length					
Maximum .....	665.5 $\mu$	601.8 $\mu$	665.5 $\mu$	573.5 $\mu$	538.1 $\mu$
Minimum .....	262.0 $\mu$	205.3 $\mu$	198.2 $\mu$	177.0 $\mu$	262.0 $\mu$
Average .....	438.3 $\mu$	401.5 $\mu$	375.7 $\mu$	416.3 $\mu$	363.2 $\mu$
Ratio .....	1:13	1:16	1:15	1:11	1:11
Perforation plate					
% scalariform 9+ bars	0	0	0	0	0
% scalariform 8— bars	49	62	73	54	65
% porous .....	51	38	27	46	35
Average no. of bars .....	4.3	4.2	4.9	3.4	3.5

Apparently considerable phylogenetic advancement has taken place within the genus which has resulted in a present day genus of rather extensive anatomical limits. The extent of anatomical variation in relation to similar variation within other genera of the subfamily is shown in figure 6. In this figure the vertical dimension of the rectangle in which each generic name appears indicates the extent of anatomical variation of that genus. It is interesting to note that the anatomical limits of the genus *Bejaria* are slightly more extensive than those of the entire neighboring tribe—the Cladothamneae. *Bejaria*, therefore, is made up of some species on the whole more advanced anatomically than any genus of the Cladothamneae and others correspondingly less advanced. This variation in anatomical structure appears to be paralleled morphologically by the variation in petal, stamen and carpellary number.

<sup>1</sup> Location of specimens studied anatomically are indicated in this and all subsequent references by herbarium, collector's name and collector's number. Herbaria are designated by the following code: New York Botanical Garden NY, United States National Herbarium US, Chicago Natural History Museum C, University of California CAL, University of North Carolina NC, Agnes Scott College AS. For those specimens not adequately identified by collector's name and number the herbarium sheet number is given, or such other information as is available.

## Tribe II CLADOTHAMNEAE Copeland

Figs. 2, 6

Corolla of 3-5 (rarely 6) free petals. Stamens 4-12, normally twice the number of corolla segments. Anthers dehiscing by longitudinal slits. Ovary of 3-5 (rarely 6) cells. Wood diffuse porous. Vessel angular in outline with thin even walls. Vessel perforation transitional between scalariform with many bars and porous. Vessel side wall pits half-bordered, elongate-elliptic opposite to round opposite, never scalariform. Tertiary thickening of vessel walls present. Medullary rays Heterogeneous Type I or Heterogeneous Type IIB.

Three genera—*Elliottia*, *Cladothamnus* and *Tripetaleia*—comprise this tribe. Of these *Elliottia* and *Cladothamnus* are monotypic and *Tripetaleia* includes two species. The set of characteristics which distinguish this group are the polypetalous corolla, wide variation in vessel perforation structure, absence of scalariform pits in wood parenchyma cells or vessel side walls and the presence of tertiary thickening of the vessel walls.

All three genera are closely related although no one genus appears to have given rise to the others. Of the three genera *Cladothamnus* (*Cladothamnus pyrolaeiflorus* Bong.; C—Cooper 130 C—Muenscher 8072) is considered to be least advanced. This belief is founded on the 5-merous (sometimes 6-merous) floral structure, the relatively high vessel diameter to length ratio and the relatively low percentage of porous vessel perforation plates.

Closely related to *Cladothamnus* is *Elliottia*. Its single species (*Elliottia racemosa* Muhl.; NC—Herbarium sheet 1618) agrees closely with *Cladothamnus* in details of vessel side wall and wood parenchyma pitting. Moreover *Elliottia* and *Cladothamnus* both have Heterogeneous type IIB medullary rays, a condition found nowhere else in the subfamily. That *Elliottia* is the more advanced is indicated by its typically 4-merous floral structure, its lower vessel diameter to length ratio and its considerably higher percentage of porous type vessel perforations.

The two species of *Tripetaleia* have at various times been regarded as constituting a separate genus or as being species of the genus *Elliottia*. In the latter case the three species thus comprising *Elliottia* are so different that some taxonomists have assigned each to a separate section of the genus. Copeland reduces *Tripetaleia bracteata* Benth. and *Tripetaleia paniculata* S & Z to *Elliottia*, although he saw no material of *T. bracteata*.

The writer has also been unable to secure material of *T. bracteata*, but anatomically *T. paniculata* (NY—Faurie 4039) differs sufficiently from *Elliottia racemosa* to warrant their treatment as species of distinct genera. Anatomically their differences are greater than those between *Elliottia* and *Cladothamnus*. Figure 2 shows manifest differences in vessel side wall and wood parenchyma pitting, in vessel perforation structure, and, quite significantly, in medullary ray type between *Tripetaleia* and its kindred genera. *Tripetaleia* further differs from *Elliottia* and *Cladothamnus* in the 3-merous nature of its floral structure.

The majority of evidence therefore supports the conclusion that *Tripetaleia* is a genus distinct from *Elliottia*.

As previously stated, it is quite improbable that any genus gave rise to either of the other two. It is much more likely that all three arose from a common ancestor. Their divergence from this common ancestor does not appear to have been simultaneous, however (figure 6). *Tripetaleia* must have branched first from the major line of development, and in the course of its development must have accelerated the acquisition of 3-merous flowers, round opposite vessel side wall and wood parenchyma pitting and a relatively high proportion of porous perforation plates. The present day retention of Heterogeneous Type I medullary rays, a large proportion of many-barred scalariform perforation plates, and a relatively high vessel diameter to length ratio are indications of the primitive structure of its ancestor.

A later divergence of the tribe's main phylogenetic line delimited *Elliotia* and *Cladothamnus*, with the former representing today the higher level of advancement. This progression appears to have been much more orderly. The primitive scalariform vessel perforation has given way to a transitional state between few-barred scalariform and porous with a correspondingly smaller average number of bars comprising the scalariform perforations. Likewise primitive scalariform pitting of the vessel side walls and of the wood parenchyma has been reduced to elongate-elliptic opposite and round opposite. Finally, the medullary rays have evolved from Heterogeneous Type I to Heterogeneous Type IIB. The two genera are so similar, in fact, that it is logical to deduce that the more advanced must have arisen from the less advanced. However, this conclusion is untenable when their vessel dimensions are compared. *Elliotia* could not have descended directly from *Cladothamnus* since it would have involved an increase in average vessel length. Both must have arisen from a form possessing characteristics common to both but with an average vessel length greater than that of *Elliotia* and a vessel diameter to length ratio greater than that of *Cladothamnus*.

According to our present knowledge, therefore, the Cladothamneae is a residual group composed of the ends of three phylogenetic lines which can be traced back to their convergence into a single, main tribal line of phylogenetic development. Such a view is strengthened by the fact that the present day distributional limits of the three genera are quite isolated, especially those of *Elliotia* and *Tripetaleia*.

### Tribe III PHYLLODOCEAE (Maximowicz) Drude

#### Figs. 3, 6

Corolla of 4-7 free or fused petals. Stamens 5-14. Anthers dehiscing by longitudinal slits throughout their entire length or by terminal pores or slits. Ovary 2-7 celled. Wood diffuse to semi-ring porous. Vessels angular in outline with thin, even walls. All perforation plates scalariform averaging more than 8 bars. Vessel side wall pits half-bordered, scalariform to elongate-elliptic opposite, to round opposite. Tertiary thickening of vessel walls absent. Medullary rays Heterogeneous Type I.

This tribe is composed of 8 genera rather closely related in spite of certain apparently incongruous dissimilarities. It obviously is a tribe occupying an intermediate position between the Cladothamneae and the Rhododendreae,

and it possesses certain characteristics of each. The combination of anatomical characters delimiting the Phyllodoceae from its neighboring tribes is the scalariform, many-barred perforation plate structure, and the absence of tertiary thickening of the vessel walls. Also, the group in general has regular flowers and small, buxoid or ericoid leaves.

As here constituted the tribe consists of the following genera: *Ledothamnus*, *Leiophyllum*, *Loiseleuria*, *Diplarche*, *Phyllodoce*, *Bryanthus* *Rhodothamnus* and *Kalmia*. On the basis of anatomical structure these genera fall naturally into three groups.

The first of these groups includes *Ledothamnus*, *Leiophyllum* and *Loiseleuria*. All three have scalariform, elongate-elliptic opposite, and round opposite types of vessel side wall and wood parenchyma pits, whereas the remaining five genera do not have the round opposite type. Of the three, *Ledothamnus* is most primitive, as would be expected from its 5-, 6- or 7-merous, polypetalous flowers. Material of two of the three recognized species was available for anatomical study and their variable characteristics are listed below:

#### LEDOTHAMNUS Meissner

Tabulation of anatomical characteristics varying between species.

*L. guyanensis* Meissn. var. *nitidus* A. C. Smith (US—Cardona 258). *L. sessiliflorus* N. E. Brown (NY—Pinkus 104).

	<i>L. guyanensis</i>	<i>L. sessiliflorus</i>
Vessel diameter		
Maximum .....	30.8 $\mu$	32.5 $\mu$
Minimum .....	14.6 $\mu$	11.4 $\mu$
Average .....	21.9 $\mu$	21.3 $\mu$
Vessel length		
Maximum .....	693.8 $\mu$	580.6 $\mu$
Minimum .....	212.4 $\mu$	198.2 $\mu$
Average .....	419.8 $\mu$	400.0 $\mu$
Ratio .....	1:19	1:19
Perforation plate		
% scalariform 9+ bars .....	87	90
% scalariform 8- bars .....	13	10
% porous .....	0	0
Average no. of bars .....	12.2	12.1

As a genus *Ledothamnus* obviously is the least advanced anatomically of its group, as may be seen from figure 3. Its very long vessels (409.9 $\mu$  average) and high vessel diameter to length ratio (1:19), considered along with its primitive vessel perforation structure bear out this conclusion, and there can be little doubt but that *Ledothamnus* also is the most primitive genus of the Phyllodoceae.

More advanced than *Ledothamnus* but evidently related to it are *Leiophyllum* and *Loiseleuria*. *Loiseleuria* is most advanced of the three as regards floral and anatomical structure. A monotypic genus (*Loiseleuria procumbens* (L.) Desvaux; NC—herbarium sheet 2235, NY—no data) it has the lowest vessel diameter to length ratio, the lowest average number of bars comprising

its vessel perforation plates and the highest percentage of few-barred scalariform perforations of any genus of this group. Furthermore, morphological advancement is shown by its sympetalous, pentamerous flowers and the highly reduced nature of its 2-3 celled ovary.

Lying between *Ledothamnus* and *Loiseleuria* is *Leiophyllum*, a genus whose two species possess characteristics of both *Ledothamnus* and *Loiseleuria*. *Leiophyllum* resembles *Ledothamnus* in general growth habit and in its polypetalous corolla. On the other hand it resembles *Loiseleuria* in its 2-3 celled ovary and in the basically 5-merous structure of its flowers. Therefore it is not at all surprising to find that, anatomically as well, *Leiophyllum* lies between *Ledothamnus* and *Loiseleuria* in complexity (figure 3). Actually, with regard to vessel dimension and perforation data it occupies a position almost half way between *Ledothamnus* and *Loiseleuria*. The following table lists specific differences within the genus.

#### LEIOPHYLLUM Pers.

Tabulation of anatomical characteristics varying between the species.

*L. buxifolium* (Berg.) Desv. (NY—P. Wilson, no number), (NC—herbarium sheet 26721). *L. Lyoni* Sweet (NY—Biltmore Herbarium 11242).

	<i>L. buxifolium</i>	<i>L. Lyoni</i>
Vessel diameter		
Maximum .....	32.5 $\mu$	32.5 $\mu$
Minimum .....	16.2 $\mu$	11.4 $\mu$
Average .....	25.3 $\mu$	21.4 $\mu$
Vessel length		
Maximum .....	495.6 $\mu$	523.9 $\mu$
Minimum .....	219.5 $\mu$	162.8 $\mu$
Average .....	348.3 $\mu$	344.8 $\mu$
Ratio .....	1:14	1:16
Perforation plate		
% scalariform 9+ bars .....	71	53
% scalariform 8— bars .....	29	47
% porous .....	0	0
Average no. of bars .....	10.0	8.8

*Diplarche*, *Phyllodoce* and *Bryanthus* make up the second generic group of the tribe. All are characterized by relatively short vessel elements with proportionately small cross-sectional diameters. Round vessel side wall and wood parenchyma pits are absent and there is a pronounced tendency toward ring porosity in wood structure. All three are low, prostrate shrubs with small, linear leaves. Their flowers are sympetalous and pentamerous, except for *Bryanthus* in which tetramery has been achieved.

*Diplarche* is the primitive member of the group. Only *D. multiflora* Hook. f. and Thoms. (CAL—Rock 10074; CAL—herbarium sheet 348690) of its two species was available for study. Its wood differs from that of *Phyllodoce* and *Bryanthus* in being diffuse porous. It lacks few-barred scalariform as well as porous perforations and its 1:15 vessel diameter to length ratio is the highest of the three genera.

*Phyllodoce* and *Bryanthus* are quite closely related. Both are characteristically of diffuse to semi-ring porous wood structure. A comparison of generic averages of vessel diameter and vessel perforation structure (figure 3) shows a striking similarity between these two genera. The main points of difference are the tetramerous floral structure of *Bryanthus* and that genus' shorter average vessel length and consequent lower vessel diameter to length ratio.

It should be pointed out that the range of specific anatomical variation within the genus *Phyllodoce* is considerable for one of its size, as is shown in the following table, and that some species overlap the generic limits of monotypic *Bryanthus* (*B. Gmelini* D. Don.; NY—Eggleston 21796) in several anatomical characteristics. This is to be expected, of course, when their evident close relationship is taken into account.

#### PHYLLODOCE Salisbury

Tabulation of anatomical characteristics varying between the species.

*P. aleutica* Heller (NY—Eyerdam 909). *P. empetriformis* D. Don. (NY—Rosen-dahl 2019). *P. caerulea* Babington (NY—Harriman, no number), (NC—Herbarium sheet 2359). *P. Breweri* Maximowicz (NY—Heller 16287). *P. glanduliflora* Coville (NY—Rydberg & Bessey 4658).

	<i>P.</i> <i>aleutica</i>	<i>P.</i> <i>empetriformis</i>	<i>P.</i> <i>caerulea</i>	<i>P.</i> <i>Breweri</i>	<i>P.</i> <i>glanduliflora</i>
Vessel diameter					
Maximum .....	22.7 $\mu$	26.0 $\mu$	34.1 $\mu$	42.2 $\mu$	30.8 $\mu$
Minimum .....	9.7 $\mu$	11.4 $\mu$	11.4 $\mu$	11.4 $\mu$	13.0 $\mu$
Average .....	16.1 $\mu$	18.0 $\mu$	22.1 $\mu$	24.0 $\mu$	20.5 $\mu$
Vessel length					
Maximum .....	424.8 $\mu$	417.7 $\mu$	410.6 $\mu$	396.5 $\mu$	332.8 $\mu$
Minimum .....	148.7 $\mu$	177.0 $\mu$	134.5 $\mu$	120.4 $\mu$	120.4 $\mu$
Average .....	288.9 $\mu$	288.2 $\mu$	259.9 $\mu$	294.5 $\mu$	257.0 $\mu$
Ratio .....	1:18	1:16	1:11	1:12	1:13
Perforation plate					
% scalariform 9+ bars	93	90	80	49	84
% scalariform 8— bars	7	10	20	51	16
% porous .....	0	0	0	0	0
Average no. of bars .....	13.9	12.9	9.7	8.6	10.5

The last generic group of the Phyllodoceae consists of *Rhodothamnus* and *Kalmia*. There is no significant difference in anatomical structure between these two genera. Both have diffuse porous wood, both lack round vessel side wall and wood parenchyma pits, and both have a very primitive type vessel perforation. In addition their flowers are pentamerous with stamens opening by apical pores (*Kalmia*), or by brief apical slits (*Rhodothamnus*).

*Kalmia* is considered to be the slightly more advanced genus (figure 3), although wide limits of anatomical variation among its species result in some being considerably more advanced and some equally less advanced than the two species of *Rhodothamnus*. Comparisons may be made from the following tables of specific anatomical data:



## RHODOTHAMNUS Reichenbach

Tabulation of anatomical characteristics varying between the species.

*R. Chamaecistus* Reichenbach (C—Herbarium sheet 300053; C—Herbarium sheet 941047; US—Fehlner, no number; herbarium sheet 811298) *R. Leachianus* (Henderson) Rehder (NY—Leach 2915).

	<i>R. Chamaecistus</i>	<i>R. Leachianus</i>
Vessel diameter		
Maximum .....	27.6 $\mu$	39.0 $\mu$
Minimum .....	13.0 $\mu$	13.0 $\mu$
Average .....	18.2 $\mu$	22.1 $\mu$
Vessel length		
Maximum .....	587.6 $\mu$	552.2 $\mu$
Minimum .....	177.0 $\mu$	141.6 $\mu$
Average .....	335.6 $\mu$	376.6 $\mu$
Ratio .....	1:18	1:17
Perforation plate		
% scalariform 9+ bars .....	100	100
% scalariform 8— bars .....	0	0
% porous .....	0	0
Average no. of bars .....	21.3	15.4

## KALMIA L.

Tabulation of anatomical characteristics varying between the species.

*K. aggregata* (Small) Copeland (NY—Britton, Britton, Wilson 14146). *K. latifolia* L. (NC—Herbarium sheet 9018; NC—Herbarium sheet 1002). *K. hirsuta* Walt. (NC—Herbarium sheet 1988). *K. polifolia* Wangenh. (NY—Howe & Lang 715). *K. angustifolia* L. (AS—no data). *K. microphylla* (Hook.) Heller (NY—Heller 16283).

	<i>K. aggregata</i>	<i>K. latifolia</i>	<i>K. hirsuta</i>	<i>K. polifolia</i>	<i>K. angustifolia</i>	<i>K. microphylla</i>
Vessel diameter						
Maximum .....	34.1 $\mu$	30.1 $\mu$	35.7 $\mu$	34.1 $\mu$	32.5 $\mu$	30.8 $\mu$
Minimum .....	14.6 $\mu$	14.6 $\mu$	14.6 $\mu$	14.6 $\mu$	14.6 $\mu$	13.0 $\mu$
Average .....	21.4 $\mu$	21.7 $\mu$	24.9 $\mu$	21.1 $\mu$	20.0 $\mu$	22.4 $\mu$
Vessel length						
Maximum .....	715.1 $\mu$	672.6 $\mu$	509.8 $\mu$	460.2 $\mu$	474.4 $\mu$	417.7 $\mu$
Minimum .....	233.6 $\mu$	212.4 $\mu$	169.9 $\mu$	177.0 $\mu$	177.0 $\mu$	134.5 $\mu$
Average .....	431.2 $\mu$	380.2 $\mu$	378.0 $\mu$	336.3 $\mu$	310.1 $\mu$	304.4 $\mu$
Ratio .....	1:20	1:18	1:15	1:16	1:16	1:14
Perforation plate						
% scalariform 9+ bars .....	100	100	95	92	100	100
% scalariform 8— bars .....	0	0	5	8	0	0
% porous .....	0	0	0	0	0	0
Average no. of bars .....	14.5	18.7	14.5	16.1	14.4	19.0

The eight genera of the Phyllodoceae undoubtedly are a natural group descended from a common ancestor. Their general habit of growth, their leaf structure, their floral structure, their absence of tertiary vessel wall thickening

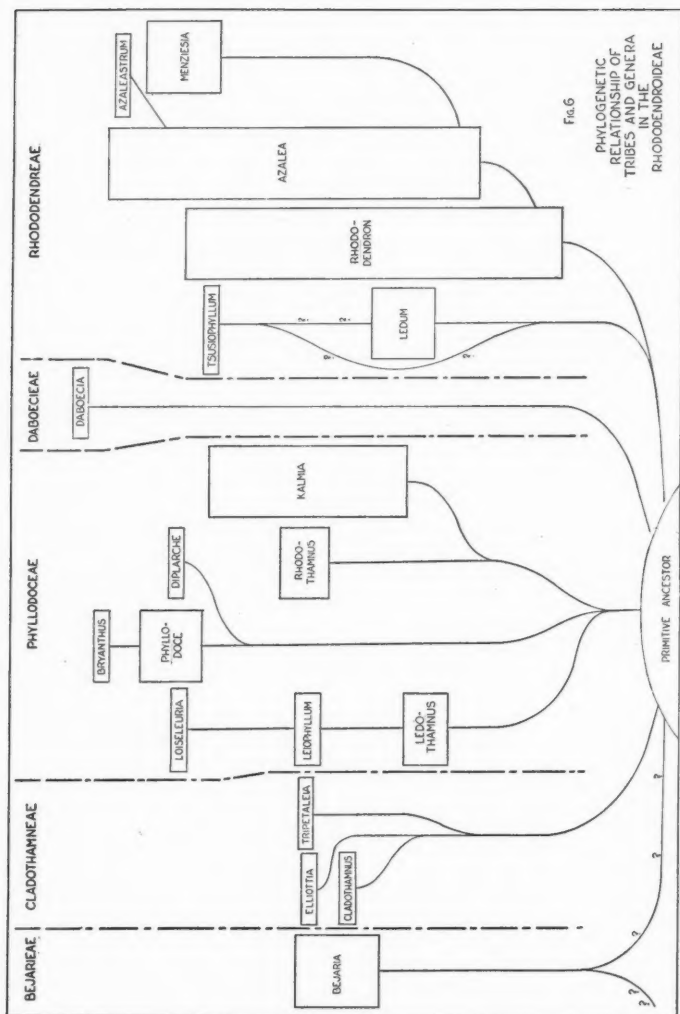


Fig. 6. Phylogenetic relationship of tribes and genera in the Rhododendroideae based on anatomical and morphological characteristics.

and of porous perforation plates, their medullary ray structure, all are evidences of this close kinship. Only some species of *Kalmia* fail to conform entirely to this general "phyllodocean" aspect, and their points of deviation are in leaf and floral structure to some extent, and in general external appearance, not in details of internal anatomy.

However the course of phylogeny in this tribe obviously is not a simple, step-by-step, genus-by-genus progression from most primitive to most advanced genus. The fact that three distinct generic groups are recognized indicates rather that three lines of development have been followed (figure 6). From the tribe's common ancestor stemmed one phylogenetic line paralleling in a few respects the development within the Cladothamneae, and represented today by *Ledothamnus*, *Leiophyllum* and *Loiseleuria*. This generic group retained many anatomical characteristics of its primitive ancestor as, for example, Heterogeneous Type I medullary rays, absence of vessel wall tertiary thickening, absence of porous perforation plates and scalariform vessel side wall pitting. Advancement was made instead in the shortening and diametric enlargement of vessel elements, the acquisition of elongate-elliptic opposite and round opposite vessel side wall and wood parenchyma pits, as well as the reduction in the average number of bars of scalariform perforations. Perhaps the greatest evolutionary step occurred, however, when the polypetalous corolla became a sympetalous one. This appears to have been accomplished in the development of *Loiseleuria* from *Leiophyllum*.

A second developmental line arose from the tribe's primitive ancestor and culminated in *Bryanthus*, *Phyllodoce* and *Diplarche*. Apparently many genera once existing as intermediate forms have been lost because the surviving group is the most advanced of the tribe. In this developmental line sympetaly was achieved, presumably in the same manner as it was in the *Ledothamnus*-*Leiophyllum*-*Loiseleuria* sequence, and in addition semi-ring porous wood appears for the first time. As a group these three genera have markedly shorter vessel elements than either of the other two groups, so development in this characteristic also seems well advanced. However, development in vessel perforation structure seems to have lagged behind evolution of other anatomical features.

As has been pointed out previously, *Bryanthus* is undoubtedly a direct and relatively recent descendent of *Phyllodoce*, but *Diplarche* probably represents an offshoot from the group's main line. *Diplarche* is on the whole more advanced than the most primitive species of *Phyllodoce* but could not have descended from it. *Diplarche* still retains diffuse porous wood structure whereas all species of *Phyllodoce* have developed a wood type intermediate between diffuse and semi-ring porous. Therefore *Diplarche* must have diverged from the line culminating in *Bryanthus* sometime before the appearance of the most primitive existing species of *Phyllodoce*.

The last group, consisting of *Rhodothamnus* and *Kalmia*, proceeded from the tribe's primitive ancestor in the general phylogenetic direction taken also by the more primitive members of the *Rhododendreae*. They developed a sympetalous corolla and some species of *Kalmia* became erect shrubs with broad leaves. Anatomically, however, both genera remain primitive. It is not thought that either genus gave rise to the other since the generic limits of

*Rhodothamnus* fall entirely within those of *Kalmia* (figure 6), and it is highly improbable that *Kalmia*'s specialized flower could have evolved during the brief period such an essentially lateral anatomical development would require. The developmental lines of *Kalmia* and *Rhodothamnus* must have parted in a way such as that shown in figure 6, with *Rhodothamnus* proceeding in accord with the tribe's conventional pattern and *Kalmia* developing certain peculiar and distinctive characteristics.

#### Tribe IV Daboecieae Tribus nova.

Figs. 4, 6

Flowers tetramerous, sympetalous. Anthers dehiscing by brief apical slits. Ovary superior, 4-celled, with relatively few ovules. Wood transitional between diffuse and semi-ring porous. Vessels angular in outline with thick and uneven walls. Vessel perforation plates strictly porous. Vessel side wall pits half-bordered, round opposite. Tertiary thickening of vessel walls absent. Medullary rays Heterogeneous Type I.

This tribe is composed of a single genus and species—*Daboecia polifolia* D. Don (C—Collector's name illegible 15609, herbarium sheet 841285; C—Magnier 920; US—Herbarium sheet 1092029). *Daboecia* previously has been considered one of the higher genera of the Phyllodoceae although its affinities with other genera are somewhat obscure. Copeland retains it in the tribe but concludes that *Daboecia* is particularly isolated among the Phyllodoceae.

The removal of *Daboecia* from the Phyllodoceae is based on anatomical rather than morphological grounds. A moderate sized shrub with tetramerous flowers and small, elliptic leaves, it differs morphologically from the Phyllodoceae primarily in anther structure and number of ovules in the ovary. Anatomically there are several significant differences between *Daboecia* and the Phyllodoceae, and it appears that their relationship is much more remote than heretofore suspected.

*Daboecia* retains some of the characteristics of its primitive ancestor such as angularity of vessel outline, absence of tertiary wall thickening of the vessels and Heterogeneous Type I medullary rays (figure 4). In these respects *Daboecia* resembles the Phyllodoceae. However, its vessel walls are thick and uneven and its vessels lack scalariform perforations entirely. These characteristics it shares with no other genus in the subfamily. Round opposite vessel side wall and wood parenchyma pits are found only in this genus, in *Tripetaleia* of the Cladothamneae and in *Azaleastrum* of the Rhododendreae. Its comparatively short ( $264.1\mu$ ) vessel elements are matched only by those of *Azaleastrum* and the *Diplarche*-Phyllodoce-*Bryanthus* group of the Phyllodoceae.

Since this tribe is monotypic one can but conjecture as to its course of phylogenetic development. As a tribe it is more closely akin to the Phyllodoceae than to any of the other tribes. Nevertheless it is hard to conceive of its having its source in any of the present day Phyllodoceae. The genus to which it appears to bear closest relationship is *Bryanthus* (figures 3 & 4), but *Bryanthus* has not developed thick, uneven walls, porous perforations or round opposite vessel side wall and wood parenchyma pits. Otherwise *Bryanthus* and *Daboecia* are at about the same relative level of advancement. It

would have been virtually impossible for all of the above mentioned advanced anatomical structures to progress as far as they have unaccompanied by at least some advancement in other structural features. The relationship between the Daboecieae and the Phyllodoceae must of necessity be more remote, and considerably so, to account for the difference in anatomical structure. It seems most reasonable to conclude that both tribes are in fact derived from the same primitive ancestor, but that their divergence from that common ancestor was prior to the establishment of tribal complements as they are recognized today (figure 6). Thus development of morphological characters in the two tribes followed parallel courses resulting in the establishment of two present day genera of apparently close relationship. However, anatomical advancement obviously was at a slightly faster pace than morphological development and *Daboecia* today remains the lone survivor of an entirely separate phylogenetic line and the most advanced genus of the subfamily.

#### Tribe V RHODODENDREAE Maximowicz

Figs. 5, 6

Flowers pentamerous or tetramerous, sympetalous (except in *Ledum*), sometimes slightly zygomorphic. Stamens 5-10. Anthers opening by terminal pores or longitudinal slits. Ovary superior, of 3-20 cells. Wood diffuse porous. Vessels angular in outline with thin and even walls. Vessel perforation plates scalariform to porous. Vessel side wall pits half-bordered, scalariform to elongate-elliptic opposite to round opposite. Tertiary thickening of vessel walls present. Medullary rays Heterogeneous Type I.

The Rhododendreae as here considered consists of the following genera: *Ledum*, *Tsusiophyllum*, *Rhododendron*, *Azalea*, *Menziesia* and *Azaleastrum*. With the exception of *Ledum* all have been traditionally grouped together in the Rhododendreae or an equivalent group. Copeland removed *Ledum* from the Ledaeae of Drude and placed it in the Rhododendreae (his Rhodoreae D. Don), close to *Rhododendron*.

The inclusion of *Ledum* makes exact delineation of tribal characters difficult. Copeland distinguishes the tribe mainly by "absence of resorption tissue in the anthers, which open through areas of collapse tissue". No specific anatomical characteristics or set of characteristics may be cited as peculiar to the tribe but in general its members may be recognized by: (1) Heterogeneous Type I medullary rays, (2) the presence of tertiary vessel wall thickening, (3) the presence in all genera but *Azaleastrum* of many-barred scalariform perforations and (4) a combination of elongate-elliptic opposite to round opposite (with or without scalariform) vessel side wall and wood parenchyma pits, again in all genera but *Azaleastrum*.

Two major lines of development emanating from a common ancestor appear to have taken place in the Rhododendreae. The first of these is discernible today in the genera *Ledum* and *Tsusiophyllum*. Quite similar in anatomical structure except for vessel dimensions, as may be seen from figure 5, their differences are in morphological structure. Monotypic *Tsusiophyllum* (*T. Tanakae* Maximowicz; CAL—Herbarium sheet 382315) is characteristically

a prostrate shrub with small, generally elliptic leaves. Its flowers are sympetalous and pentamerous, although its ovary is normally of but 3 carpels.

In contrast to *Tsusiophyllum* the four species of *Ledum* are polypetalous. Also their basically pentamerous floral structure varies only in the number of stamens which may be less than ten in two of the species. In general habit they are moderate sized shrubs with essentially elliptic, rather small leaves.

Copeland's decision to place *Ledum* in the Rhododendreae is corroborated by this anatomical study. *Ledum* can not be placed in the Phyllodoceae because of its vessel wall tertiary thickening. It does not naturally fall in the Cladothamneae because *Ledum* is devoid of porous vessel perforations and its vessel side wall and wood parenchyma pitting is not characteristic of that tribe. Likewise its relationship to the Daboeciae and Bejarieae obviously are not close. Only in the Rhododendreae are its anatomical characteristics matched by those of other genera. In this group it corresponds most closely to *Tsusiophyllum* and *Rhododendron* (figure 5).

*Ledum's* anatomical characteristics vary considerably within the species of the genus as is shown by the following table:

#### LEDUM L.

Tabulation of anatomical characteristics varying between the species.

*L. groenlandicum* Oeder (NY—Moyle 176). *L. glandulosum* Nuttall (NC—Adams 45). *L. palustre* L. (NC—Herbarium sheet 1999). *L. columbianum* Piper (NY—Abrams & Benson 11277).

	<i>L. groenlandicum</i>	<i>L. glandulosum</i>	<i>L. palustre</i>	<i>L. columbianum</i>
Vessel diameter				
Maximum .....	32.5μ	32.5μ	27.6μ	29.2μ
Minimum .....	13.0μ	14.6μ	13.0μ	11.4μ
Average .....	22.2μ	20.1μ	20.3μ	20.0μ
Vessel length				
Maximum .....	467.0μ	389.4μ	495.6μ	453.1μ
Minimum .....	226.6μ	162.8μ	134.5μ	141.6μ
Average .....	346.9μ	316.5μ	312.9μ	303.8μ
Ratio .....	1:13	1:16	1:15	1:15
Vessel perforation				
% scalariform 9+ bars ..	97	93	90	92
% scalariform 8— bars ..	3	7	10	8
% porous .....	0	0	0	0
Average no. of bars .....	13.0	12.1	13.3	11.5

However, as a genus its anatomical development is on a par with *Rhododendron* and *Tsusiophyllum*. Phylogenetic development in this part of the tribe must have been manifested principally in morphological specialization. *Ledum*, in the course of its descent from its hypothetical ancestor, has developed some evidences of anatomical advancement but has retained a primitive, polypetalous corolla.

*Tsusiophyllum* probably arose directly from one of the lower species of *Ledum* or possibly branched from the *Ledum* line sometime prior to the formation of the existing species of *Ledum*. Fusion of petals into a sympetalous corolla and reduction in carpellary number attended this evolutionary advance.

The second tribal line of development branched quite early from the *Ledum-Tsusiophyllum* line and resulted in the establishment of *Rhododendron*, *Azalea*, *Menziesia* and *Azaleastrum*. *Rhododendron* occupies the most primitive position in this sequence, as a comparison of data in figure 5 will show. That *Ledum* and *Rhododendron* are of such similar anatomical structure clearly signifies that they are derived from the same ancestor. However, sympetaly obviously was attained much earlier in this line of development than in that leading to *Ledum* and *Tsusiophyllum*, since even the most primitive species of *Rhododendron* are sympetalous.

Within the genus *Rhododendron* is great specific anatomical variation. It may be seen from the following table, and from figures 5 & 6, that anatomically some species are the most primitive in the entire subfamily and some are among the more highly advanced.

#### RHODODENDRON L.

Tabulation of anatomical characteristics varying between the species.

*R. maximum* L. (NC—Herbarium sheet 14828). *R. butrycium* Ward (NY—Ward 251). *R. apoanum* Stein (NY—Copeland 1440). *R. ponticum* L. (NY—Moldenke 8901). *R. eclectecum* Balf. f. & Forrest (NY—22592). *R. ericoides* Low. (NY—J. & M. S. Clemens 27104). *R. catawbiense* Mchx. (NC—Herbarium sheet 5680). (AS—Matthews no number).

	<i>R. maxi- mum</i>	<i>R. butry- cium</i>	<i>R. apo- anum</i>	<i>R. ponti- cum</i>	<i>R. eclec- tecum</i>	<i>R. eri- coides</i>	<i>R. cataw- biense</i>
Vessel diameter							
Maximum .....	26.0μ	22.7μ	32.5μ	40.6μ	30.8μ	22.7μ	34.1μ
Minimum .....	11.4μ	11.4μ	13.0μ	14.6μ	13.0μ	8.1μ	11.4μ
Average .....	18.5μ	17.3μ	24.3μ	25.8μ	21.4μ	15.6μ	22.2μ
Vessel length							
Maximum .....	651.4μ	495.6μ	764.6μ	658.4μ	417.7μ	512.8μ	516.8μ
Minimum .....	226.6μ	162.8μ	240.7μ	198.2μ	155.8μ	181.1μ	148.7μ
Average .....	438.3μ	360.4μ	513.3μ	452.4μ	281.1μ	332.1μ	328.5μ
Ratio .....	1:24	1:21	1:21	1:18	1:13	1:21	1:15
Perforation plate							
% scalariform							
9+ bars .....	100	100	100	100	100	83	57
% scalariform							
8— bars .....	0	0	0	0	0	17	43
% porous .....	0	0	0	0	0	0	0
Average no. of bars .....	13.9	20.4	13.3	15.8	14.1	11.0	8.8

This denotes the fact that considerable phylogenetic development has occurred within the confines of our presently defined genus *Rhododendron*.

This conclusion applies equally as well to *Azalea* (see following table and figures 5 & 6) whose species differ anatomically from *Rhododendron* in two respects: (1) the absence of scalariform vessel sidewall and wood parenchyma pits, and (2) the presence of porous vessel perforation plates.



## AZALEA L.

Tabulation of anatomical characteristics varying between the species.

*A. calendulacea* Mchx. (AS—Johnson no number). *A. nudiflora* L. (NC—Herbarium sheet 12152). *A. canescens* Mchx. (AS—Cobb no number). *A. canadensis* O. Kuntze (NY—Clark & Seymour 691). *A. californica* T. & G. (NY—Chandler 1448). *A. lapponica* (R. lapponicum Whlbg) L. (NY—Knight no number). *A. serrulata* Small (NY—Rugel no number). *A. vaseyi* Rehder (NY—Heller no number).

	<i>A. calen-</i> <i>dulacea</i>	<i>A. nudi</i> <i>flora</i>	<i>A. canes-</i> <i>cens</i>	<i>A. cana-</i> <i>densis</i>	<i>A. cal-</i> <i>ifornica</i>	<i>A. lapponi-</i> <i>ca</i>	<i>A. ser-</i> <i>rulata</i>	<i>A.</i> <i>vaseyi</i>
Vessel diameter								
Maximum ....	45.4 $\mu$	30.8 $\mu$	30.8 $\mu$	34.1 $\mu$	37.3 $\mu$	29.2 $\mu$	40.6 $\mu$	30.8 $\mu$
Minimum ....	9.7 $\mu$	9.7 $\mu$	13.0 $\mu$	14.6 $\mu$	11.4 $\mu$	9.7 $\mu$	17.9 $\mu$	16.2 $\mu$
Average .....	23.7 $\mu$	19.4 $\mu$	20.1 $\mu$	21.3 $\mu$	22.6 $\mu$	16.7 $\mu$	26.6 $\mu$	23.3 $\mu$
Vessel length								
Maximum ....	708.0 $\mu$	467.3 $\mu$	460.2 $\mu$	424.8 $\mu$	516.8 $\mu$	318.6 $\mu$	594.7 $\mu$	446.0 $\mu$
Minimum ....	262.0 $\mu$	205.3 $\mu$	191.2 $\mu$	155.8 $\mu$	219.5 $\mu$	127.4 $\mu$	184.1 $\mu$	120.4 $\mu$
Average .....	448.1 $\mu$	372.5 $\mu$	331.4 $\mu$	334.2 $\mu$	345.5 $\mu$	232.6 $\mu$	356.8 $\mu$	305.8 $\mu$
Ratio .....	1:19	1:19	1:16	1:16	1:15	1:14	1:13	1:13
Perforation plate								
% scalariform								
9+ bars ..	36	7	21	4	16	9	13	3
% scalariform								
8— bars ..	32	17	28	46	40	66	10	76
% porous ....	32	76	52	50	44	25	77	21
Average no. of bars ....	9.3	7.3	8.6	4.9	6.4	5.2	9.0	5.2

*Azalea* is of course quite closely related to *Rhododendron* and is considered by some, Drude for example, to be at the most a section of the genus *Rhododendron*. These two anatomical differences, when added to recognized differences in morphology, seem to support the more recent taxonomic practice of separating the genera.

As indicated in the above table *Rhododendron lapponicum* has been returned to its original position in the genus *Azalea*. It was thought to have been misclassified originally because it may have 5 or 10 stamens and was subsequently removed to *Rhododendron*. Its anatomical structure is clearly that of *Azalea*, however, and the fact that there may be 10 stamens occasionally is undoubtedly to be considered a retention of a primitive characteristic.

As a genus *Azalea* is more advanced than *Rhododendron* and undoubtedly arose directly from it. It is quite possible that some species of *Azalea* may have developed singly from less advanced species of *Rhododendron* but this is not considered likely. The homogeneity of anatomical characteristics in each genus indicates rather that the most primitive species of *Azalea* developed from a primitive species of *Rhododendron* and that subsequently the genera have undergone a long period of parallel evolution. Such a development involved stabilization of carpellary number, reduction in number of stamens from basically 10 to basically 5, acquisition of porous perforation plates, and loss of scalariform vessel side wall and wood parenchyma pits.

*Azaleastrum* is a peculiar genus which undoubtedly arose as a short, lateral branch from the *Azalea* generic line. Morphologically this genus is distinguished from its parent genus only by minor details of inflorescence. Only one of its 23 species was available for anatomical study but it (*A. albiflorum* Rhed.; NY—Shaw 907) shows several interesting anatomical features (figure 5). Vessel element average length is considerably shorter than the average for *Azalea* but not as short as some of the higher species of *Azalea*. It has lost all scalariform many-barred perforations and its vessel side wall and wood parenchyma pits are round opposite only. Thus *Azaleastrum* must have developed directly from one of *Azalea*'s higher species, this development being one of specialization in pit and perforation structure (figure 6).

*Menziesia* is a genus whose floral structure seems to be undergoing the transition from pentamery to tetramery. Otherwise, morphologically and anatomically it is quite closely related to *Azalea* and *Rhododendron*. All three have slightly zygomorphic, sympetalous flowers, awnless anthers opening by terminal pores, and many similar anatomical features. *Menziesia* is more closely related to *Azalea* than *Rhododendron* in certain distinguishing anatomical characteristics of perforation and pit structure. As a genus *Menziesia* is more advanced than *Azalea* but the upper and lower limits of specific anatomical variation in *Azalea* exceed those of *Menziesia* (figure 6 and following table).

#### MENZIESIA Smith

*M. pilosa* Persoon (NC—Herbarium sheet 2289). *M. ferruginea* Smith (NY—Mertens no number). *M. glabella* Gray (NY—MacDougal 552).

	<i>M. pilosa</i>	<i>M. ferruginea</i>	<i>M. glabella</i>
Vessel diameter			
Maximum .....	38.9 $\mu$	37.3 $\mu$	39.0 $\mu$
Minimum .....	11.4 $\mu$	16.2 $\mu$	14.6 $\mu$
Average .....	21.7 $\mu$	26.8 $\mu$	24.9 $\mu$
Vessel length			
Maximum .....	516.8 $\mu$	488.5 $\mu$	403.6 $\mu$
Minimum .....	141.6 $\mu$	184.1 $\mu$	127.4 $\mu$
Average .....	315.0 $\mu$	314.3 $\mu$	277.5 $\mu$
Ratio .....	1:15	1:12	1:11
Perforation plate			
% scalariform 9+ bars .....	50	33	13
% scalariform 8— bars .....	47	60	74
% porous .....	3	7	13
Average no. of bars .....	8.1	7.2	5.5

*Menziesia* thus could not have developed as a direct descendant of the most advanced species of *Azalea* but must have arisen from one of the lower species (figure 6). This accounts for the fact that *Menziesia*'s average percentage of porous perforation plates is lower than the average for *Azalea*, and also indicates that the major phylogenetic trend was, and is the reduction in number of floral structural units.

The tribe as a whole appears to have developed along two main developmental lines which diverged from a common ancestor some time before the

establishment of present day Rhododendrean genera. One of these lines culminated in *Ledum* and *Tsusiophyllum* and was characterized by great morphological changes. The other line was distinguished by similar morphological changes plus corresponding anatomical developments resulting in the establishment of two great genera demonstrating considerable variation within themselves, and two smaller, less variable genera.

### Concluding Remarks

The foregoing discussion of relationships between genera in the Rhododendroideae has been predicated upon that group's development along five great phylogenetic lines. These are recognized today as five tribes of the subfamily. The question inevitably arises as to whether the subfamily is of monophyletic or polyphyletic origin.

On the basis of our present knowledge of this group's anatomy and morphology it is possible that all genera are of monophyletic origin and, with the exception of *Bejaria*, such an origin is quite probable. An hypothetical ancestor which could have given rise to all tribes but the Bejariaceae would of course be quite primitive in structure. It would be a shrub with regular, polypetalous, at least 7- or 8-merous flowers. Its ovary would be superior and composed of not less than 20 carpels. Anatomical specialization likewise would be slight. Its wood undoubtedly would be diffuse porous and its medullary rays Heterogeneous Type I. Vessels would be long and slender with a vessel diameter to length ratio exceeding 1:24. In outline they would be angular and their walls would be thin and even with no tertiary thickening. Many-barred scalariform perforations of the highly inclined vessel end walls would be characteristic as would be scalariform vessel side wall and wood parenchyma pits.

From this ancestor could have arisen the Cladothamneae, Phyllodoceae, Daboeciae and Rhododendreae and possibly the Bejariaceae (figure 6). The general Cladothamnean developmental line was characterized by reduction in number of floral parts, reduction in vessel diameter to length ratio, reduction in number of bars comprising the scalariform perforations and eventual acquisition of some porous perforations, development of elongate-elliptic to round vessel side wall and wood parenchyma pits, acquisition of tertiary vessel wall thickening and development of Heterogeneous Type IIB medullary rays.

The Phyllodocean line was distinguished by the incomplete development of semi-ring porous wood, reduction in vessel diameter to length ratio, reduction in number of bars of the scalariform perforations, reduction in number of floral parts and eventual attainment of sympetaly. Many primitive characteristics were retained, such as scalariform vessel side wall and wood parenchyma pits, Heterogeneous Type I medullary rays, and the absence of porous perforations and vessel wall tertiary thickening.

Development of the Daboecian line was marked by reduction in number of floral parts, by achievement of sympetaly, and by many anatomical advances. Some of these were thick, uneven vessel walls, complete loss of scalariform perforations, development of round opposite pits and partial development of semi-ring porous wood.

The Rhododendrean line showed early development of sympetaly and slight zygomorphy, as well as tertiary thickening of the vessel walls. Other advances appeared as gradual acquisition of round vessel side wall and wood parenchyma pits, development of porous perforation plates and reduction in vessel diameter to length ratio.

The relationship of the Bejariaceae to the other tribes is more remote. It is difficult to conceive of *Bejaria* having arisen from the same ancestor as the other four tribes and to have at present such a combination of primitive morphological and advanced anatomical characteristics. This supposed derivation would have entailed virtually no morphological changes but vast anatomical changes. *Bejaria's* floral structure is practically identical, save in carpellary number, with that of the "reconstructed" ancestor of the other tribes. Yet *Bejaria* is by no means primitive anatomically, in comparison with other genera of the subfamily. Logically then, *Bejaria* is not descended from the ancestor of the remaining Rhododendroideae and we must look elsewhere for its predecessor. At present no light can be shed upon its probable source since there is only sparse and inconclusive anatomical data available for any of the suspected ancestors of this subfamily. It is, therefore, highly probable that the Rhododendroideae is of polyphyletic origin.

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## A New *Collinsia* In Illinois

George D. Fuller  
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The species *Collinsia verna* Nutt. is well known through the state ranging from Winnebago County in the north to Union County in the south, but usually occurring in widely separated moist woodlands. Until very recently this has been regarded as the only species occurring in Illinois in spite of rumors to the contrary.

In May, 1947, inspired by reports of another species of this attractive spring flower growing in the center of the state, the writer, accompanied by Professor G. Neville Jones of the University of Illinois, made an exploring field trip to Shelby County. At the town of Shelbyville we were joined by two local naturalists, Messrs. U. L. Evans and Vance Courtright, who took us to two localities where the new species had been growing, according to our guides, for at least 15 years. The first locality was a hillside where the prairie sloped to the narrow flood plain of the Kaskaskia River. On this hillside growing in light sandy soil, in an open woods and stretching over an area of some hundred square yards we found the plant in full bloom. There were several thousand plants varying in height from 6 to 20 inches tall, sparingly branched.

Another stand of the same plant was also visited, three miles distant from the first, on a moraine hill some seven miles southwest of Shelbyville. This hill, known as Williamsburg Hill, rises 200 feet above the surrounding plain. On a similarly sloping hillside in similar sandy soil, partially shaded by an open oak woods was a somewhat larger stand of this plant which was readily determined by Professor Jones as *Collinsia violacea* Nutt. and specimens are being preserved in the herbarium of the University of Illinois at Urbana and in the herbarium of the Illinois State Museum at Springfield, Illinois.

In Pennell's<sup>1</sup> discussion of this species he gives a map of its distribution showing its occurrence in rich soil in Missouri, Kansas and Arkansas to Texas, and from that map it seems that the distance between the stands in Shelby County, Illinois, and the nearest stand recorded on the map, that in southeastern Missouri in Durkin County, is about 200 miles.

The collection data are as follows:

*Illinois:* On a sandy hillside, locally abundant, 5 miles south of Shelbyville, SHELBY COUNTY. May 17, 1947. G. D. Fuller, No. 12697; May 12, 1947; U. L. Evans, No. 12694, and 7 miles S-W of Shelbyville on Williamsburg Hill, locally abundant, G. D. Fuller, No. 12724 in the State Museum, Springfield, and G. N. Jones, Nos. 1704, 1705 in herbarium of University of Illinois, Urbana, Ill.

<sup>1</sup> PENNELL, F. W. The Scrophulariaceae of eastern temperate North America. Acad. Nat. Sci. Philadelphia, Monog. 1:1-650. 1935.

## Carbon Dioxide Concentration of the Atmosphere Above Illinois Forest and Grassland

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The statements are commonly made in biological text books and lectures that the carbon dioxide content of the air approximates .03 to .04% and that carbon dioxide is the limiting factor in photosynthesis. These generalizations are basically sound and are scientifically justifiable, but their unqualified acceptance may lead to a dogmatic assurance that they are always true. Actually, the carbon dioxide content of the air varies at different levels and the traditional value of .03-.04% for carbon dioxide concentration is an average; the carbon dioxide content of the air infrequently falls below .03%, but often exceeds .04%. Under conditions of low light intensity and a relatively high carbon dioxide concentration of the air, light intensity, rather than carbon dioxide concentration, becomes the limiting factor in photosynthesis.

Lundegårdh has contributed extensively to the knowledge of the concentration of atmospheric carbon dioxide and has reviewed the investigations of other scientists in this field. The observations of these investigators indicate that the carbon dioxide concentration of the atmosphere is highest immediately above the soil, where it may be four or five times greater than the concentration of carbon dioxide at a height of one meter above the soil surface. The relatively high carbon dioxide concentrations close to the soil are the result of diffusion of carbon dioxide from the soil, in which it frequently reaches concentrations greater than 1%. The source of this carbon dioxide is chiefly respiration of bacteria, plant roots, and soil animals. The production of carbon dioxide by soil varies with such factors as temperature, aeration, and the fertility of the soil. Heavy fertilizing of soils commonly increases the production of carbon dioxide, since it stimulates bacterial activity and the growth and respiration of roots.

This brief paper reports some observations on the carbon dioxide concentrations at various levels of the atmosphere in forest and grassland habitats in Champaign county, Illinois. Samples of air were taken in glass tubes with a capacity of 100 ml. and with open ends. The tubes were placed in horizontal positions, in which they were permitted to remain for one hour. At the end of this interval, the tubes were tightly plugged with rubber stoppers, which were sealed with adhesive tape before transportation to the laboratory. Air samples at the soil surface were obtained by permitting the glass tubes to lie on the soil surface. Samples were taken also at heights of 7-8 cm., 15-16 cm., 30-31 cm., 60-61 cm., and 91-92 cm. above the soil surface. Analyses of the air samples were made with the Haldane gas analysis apparatus. The results are indicated in volume percentages in the accompanying tables. Each figure in the tables represents the average of four determinations of four samples taken simultaneously.

TABLE 1.—Carbon dioxide of the Atmosphere in Brownfield Woods, Champaign County, Illinois. June 22, 1941—1 p. m.

<i>Height above soil</i>	<i>% CO<sub>2</sub> in air</i>
0-1 cm. ....	.127
7-8 cm. ....	.061
15-16 cm. ....	.041
30-31 cm. ....	.035
60-61 cm. ....	.032
91-92 cm. ....	.037

TABLE 2.—Same as Table 1. June 27, 1941—1 p. m.

<i>Height above soil</i>	<i>% CO<sub>2</sub> in air</i>
0-1 cm. ....	.138
7-8 cm. ....	.054
15-16 cm. ....	.042
30-31 cm. ....	.039
60-61 cm. ....	.039
91-92 cm. ....	.040

TABLE 3.—Carbon dioxide of the atmosphere in Trelease Woods, Champaign County, Illinois. June 29, 1941—1 p. m.

<i>Height above soil</i>	<i>% CO<sub>2</sub> in air</i>
0-1 cm. ....	.101
7-8 cm. ....	.051
15-16 cm. ....	.042
30-31 cm. ....	.045
60-61 cm. ....	.038
90-91 cm. ....	.042

TABLE 4.—Carbon dioxide of the atmosphere, grassland, 1 mi. E. of Urbana, Illinois. June 24, 1941—1 p. m.

<i>Height above soil</i>	<i>% CO<sub>2</sub> in air</i>
0-1 cm. ....	.098
7-8 cm. ....	.050
15-16 cm. ....	.036
30-31 cm. ....	.041
60-61 cm. ....	.029
91-92 cm. ....	.032

TABLE 5.—Same as Table 4. June 26, 1941—1 p. m.

<i>Height above soil</i>	<i>% CO<sub>2</sub> in air</i>
0-1 cm. ....	.073
7-8 cm. ....	.053
15-16 cm. ....	.035
30-31 cm. ....	.035
60-61 cm. ....	.038
91-92 cm. ....	.027



TABLE 6.—Carbon dioxide of the atmosphere, river bottom, Sangamon River, Mahomet, Illinois (dense shade of wooded banks). July 9, 1941—1 p. m.

Height above soil	% CO <sub>2</sub> in air
0-1 cm. ....	.181
7-8 cm. ....	.099
15-16 cm. ....	.050
30-31 cm. ....	.047
60-61 cm. ....	.036
91-92 cm. ....	.039

The following conclusions, relevant to the specific habitats studied, can be derived from the data presented in these tables:

1. In the forest, grassland, and river bottom habitats studied, the concentration of carbon dioxide in the atmosphere at the soil surface was distinctly higher than the .03-.04% concentrations commonly cited. The highest concentration found was .181% at the soil surface of a densely wooded river bottom.

2. There is a steep gradient of carbon dioxide concentrations from the atmosphere at the soil surface to that at nearly one meter above the soil surface.

3. A fairly high concentration of carbon dioxide occurs up to 8 cm. above the soil surface. Above this height, the concentration rarely exceeds the commonly cited percentage of .03-.04.

4. The carbon dioxide concentration at the soil surfaces of forest and of forested river bottom land is significantly higher than that at the soil surface of grassland. The explanation of this difference lies doubtless in the more sluggish and less extensive air movement in densely wooded areas.

5. Lower leaves of low-growing plants have access to higher concentrations of carbon dioxide than do the upper leaves. Low-growing plants, such as mosses, liverworts, and prostrate creepers especially in wooded areas, probably live largely or entirely in an atmosphere of higher carbon dioxide supply than do erect plants which bear most of their leaves at heights above 8 cm.

The results of this investigation suggest that, at near-soil atmospheric levels in forests under a condition of low light intensity, carbon dioxide is present in such concentrations that it is not the limiting factor in photosynthesis, but that light intensity probably sets the maximum rate of this process. This aspect of the carbon dioxide-light-photosynthesis relationship, which is commonly overlooked in instruction in general botany and plant physiology, deserves greater emphasis.

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Gustav Fisher.

## Book Reviews

FLORA OF KALAMAZOO COUNTY, MICHIGAN, VASCULAR PLANTS. By Clarence R. and Florence Hanes. Privately Published, 1947. xii+295 pages. \$4.00 postpaid. For sale by the authors, Schoolcraft, Michigan.

Norman Fassett once remarked that before we can discuss plant distribution intelligently in the United States we shall have to have forty-seven other C. C. Deams, one to each state. The appearance of this attractive *Flora* by Mr. and Mrs. Hanes will reduce the number by one more. To a lifelong familiarity with the flora of southwestern Michigan, they have added over a decade of careful, detailed collecting. The results of this intensive study are presented with meticulous attention to bibliographic detail in an attractively bound volume of somewhat over three hundred pages (300, that is, if we include the blank pages for additional notes which are bound in at the end of the volume).

To a terrain endowed by Pleistocene glaciation with a great variety of habitats, they have brought sharp eyes, patient industry, and the long-time resident's understanding of just where to look. As a result they present for one Michigan county the almost incredible total of 1,749 species, varieties, and forms, around fifty of which are new to the *Flora* of Michigan. Of these nearly half are blackberries. The authors have worked in close collaboration with L. H. Bailey as they have also with various other monographers. For those who would like to assess the probable significance of speciation in North American Rubi, their volume with its detailed record of the blackberries of a small area will be a valuable addition to L. H. Bailey's extensive consideration of the same subject.

The volume is handsomely printed and so well bound that it will lie open upon the desk without one's having to break its back, or use a paper weight. Bailey has supplied cuts of several of the new species of blackberries published here for the first time; there is an outline map of the county and a frontispiece showing the frostweed set with the ice flanges to which it owes its common name. There is an excellent index of common and scientific names and a comprehensive Table of Contents. This is, however, more than just another local flora. Two gifted people have been living with an interesting flora and one can scarcely turn to a page which does not bear witness to original observation. The following quotations are typical and could be matched by many more.

"*Cystopteris fragilis* var. *protrusa* . . . among the first ferns to appear in the spring. The earlier fronds may die in July and a second growth come in August and September."

"From the shag-bark, small fruited, and bitter hickories a pleasant tasting syrup is often produced. When the hickory is tapped the exudation is not sap, but is almost as thick as syrup. The fresh stumps of March-cut trees have given us pleasant tastes of syrup, which had collected near the perimeter of the stump."

Under *Nyssa sylvatica* one reads, "There are apparently two forms of this species in Kalamazoo County. The one has subcoriaceous lanceolate-shaped leaves; in the other the leaves are more elliptical in outline and are thinner in texture. The leaves of the first are bright red at maturity and shiny above; the leaves of the second dull red or merely yellow and without luster. Trees of the first form were still in full leaf while those of the second had become almost bare."

While both Mr. and Mrs. Hanes are college trained and have been interested in botany since high school days, neither of them had any technical training in modern taxonomic techniques. Their intelligence and persistence are reflected in the technical accuracy of their flora as well as in the large number of species and varieties they have been able to discover in so small an area.—EDGAR ANDERSON, Missouri Botanical Garden, St. Louis.

GENERAL BIOLOGY. By Perry D. Strausbaugh and Bernal R. Weimer. John Wiley & Sons, Inc., New York City. 1947. 2nd Ed., vii+718 pp., 360 figs., 28 pls. \$4.75.

The second edition of this comprehensive textbook has numerous constructive changes and complete additions yet retains the same general plan of the first edition. The authors have wisely revised the text upon the sound belief that principles should be stressed as groundwork for more specific studies. To that end the greater part of the book is devoted, with illustrations being drawn from both zoological and botanical sources and with a nice balance between anatomy and physiology.

Pictorially, this edition is considerably improved over the first by the use of stereograms and combinations of photographs and accompanying drawings which should be of assistance to students in laboratory studies.

It is felt that the chapters on phylogeny of the animal kingdom have suffered not so much in text as emphasized in this edition. Whereas, in the first edition there was maintained a clear-cut step-by-step discussion of phylogeny, this edition has certain features of especial interest to man elevated in page headings and paragraph titles to the point which may make it difficult for the elementary student to retain continuity of subject material and emphasis. This criticism does not hold for chapters on phylogeny of plants, which have been expanded along lines of the first edition but with considerable improvement, especially in studies of the Thallophyta.

It is the feeling of the reviewer that, in spite of such anachronisms as chromosomes linked end-to-end in spindles and such omissions at this date as lack of mention of the Rh blood factors, there is a wealth of material in this text for the really interested student of biology. However, it is a text written not for the use of uninspired or undiscerning teachers who insist on strict and unflinching adherence to the word of the text; nor do the authors make concession to the student by trying to present biology in the form of a pabulum to be taken without due thought. Most teachers and students will find that there has been an honest effort on the part of the authors to include, as well and completely as possible in an elementary text, all phases of theoretical and applied biology.—LOUIS E. DELANNEY, University of Notre Dame, Notre Dame, Indiana.

LOGBOOK FOR GRACE WHALING BRIG DAISY, 1912-1913. By Robert Cushman Murphy. The Macmillan Company, New York. 1947. x+290 pp., line drawings in text. \$4.00.

Not a few of the travel books written by naturalists recount the experiences of the very journey or voyage that made them, in fact, naturalists. This is the case with *The Naturalist's Voyage around the World*, which is the prototype of this segment of travel literature; and it is in large part the case with *A Logbook for Grace*, for Bob Murphy was only 25 when he sailed and was still only at the beginning of a subsequently distinguished career as ornithologist, geographer, and oceanographer. In the modern world of books written with the one thought of immediate publication (and usually contracted for even before they are written), it is refreshing to read a book written for the eyes of a single person. "Grace" was the young bride whose intelligent appreciation of the value of a naturalist as husband and of the importance of having him be a really good one is fundamentally responsible for both journey and diary. It is the fact that the book was written for an intelligent and extremely interested reader that gives *Logbook for Grace* its freshness and charm. The young naturalist's serious interest fills the pages of his diary with first-hand accounts of the old-fashioned small-boat whaling, the ways in which whalers distinguish the species of whales, landings on remote Atlantic islands, observations on such distinguished birds as the albatrosses, and with notes on the extraordinary zoology of the Antarctic islands of South Georgia, with its sea elephants and penguins. The account describes most vividly the activities of a museum collector. These were eminently productive, but it is now evident that the really great success of the voyage was Robert Cushman Murphy's confirmation in a naturalist's career.

The somewhat heterogeneous account of varied observations is given a degree of unity by the continuity of the voyage, by its focus on the animal life of the sea, by the

confinement and intimate human relations of the ship, and by the reflected and charming love story from real life.—KARL P. SCHMIDT, Chicago Natural History Museum, Chicago, Illinois.

GUIDE TO THE STUDY OF THE ANATOMY OF THE SHARK, NECTURUS, AND THE CAT.

By Samuel Eddy, Clarence P. Oliver, and John P. Turner. John Wiley & Sons, New York; Chapman & Hall, London. 1947. 2nd ed., viii + 115 pp., 17 figs. \$1.75.

The manual is well organized, carefully written, and concise. The treatment, adaptable to varying needs, is exceedingly practical for small schools and institutions where laboratory space and equipment are limited and for curricula calling for maximum coverage in a minimum of time. Especially commendable are the skill and good judgment with which the authors "stick" to the more fundamental and important aspects of the subject. They stress careful and detailed dissection and the directions therefor are generally lucid, logical, and precise; the more difficult phases are clearly illustrated by wisely selected outline drawings. The chapter on the teleost skull, included as a supplement to the work on the elasmobranch skeleton, is particularly welcome. The value of sketching in connection with dissecting is perhaps unduly minimized—nothing in the presentation prevents the instructor from requiring as much drawing as he may feel advised but the fact that such assignments appear to be additional to the expectations of the manual provides the occasional recalcitrant student with grounds for unpleasant argument.—R. CHESTER HUGHES, Oklahoma A. & M. College, Stillwater.

AMPHIBIANS AND REPTILES OF THE PACIFIC STATES. By Gayle Pickwell. Stanford

University Press, Stanford University, California. 1947. xiv + 236 pages, 20 figs., 64 plates. \$4.00.

The extremely good impression made by Professor Pickwell's earlier books of photographs is largely, though not quite uniformly, sustained in the present work. The identification of nearly all species in the three Pacific states is made easy by the photographs and keys, and there are admirable illustrations of the swallowing of food, of the skin-shedding process, of the activities of the enemies of lizards and snakes and tadpoles, of the eggs of frogs and salamanders and lizards, and of some of the most characteristic habitats as landscapes. Professor Pickwell has turned to excellent advisors at Stanford University and elsewhere for criticism and aid, and the classification and nomenclature are thoroughly up-to-date.

All his advisors, together with the editors of the Stanford University Press have failed to note that modern usage has long since given up the capitalization of common names (see any dictionary), let alone of such general terms as "salamander" and "lizard." It is especially disturbing to read in the introductory chapter that the author has a high regard for the learning of such jawbreaking terms as *poikilothermal* and *homoiothermal*, thereby almost converting the reviewer to the more recent *ectothermal* and *endothermal*, as at least more readily pronounceable. All four terms, however, could well have been avoided in so essentially introductory a volume. West Coast children may henceforth be forgiven if they refer to their parents as those old *homoiotherms* and to Friday as *Poikilotherm Day*.

In so well-known a fauna it would have been better to analyze the opportunities for field and laboratory observation, and to have placed less emphasis on collecting and identification.

Professor Pickwell adds that "The ability to use a key properly is the first step in acquiring that definite impression that one is 'becoming a scientist.'" I can only recommend to him that classic among zoological keys, the one to the *Fishes of Alachua County, Florida*; and go back to thumbing my Boulenger if some slackening of editorial duties should enable me again to try to identify a few specimens from regions less well known than the Pacific states.—KARL P. SCHMIDT, Chicago Natural History Museum, Chicago, Ill.

MAMMALS OF CALIFORNIA. By Lloyd Glenn Ingles. Stanford University Press, Stanford University, California. 1947. 258 pages, 42 plates, 57 figures. \$4.00.

It is fortunate that animals and plants know no political boundaries, but rather are limited in their distribution by life zones or biomes. State lists serve a useful purpose, but in the fullness of time, we must consider biological, geological and other natural unities in discussing the various life classes. Until such time, state reports of plants and animals must serve.

Of the many books and reports on the various vertebrates, the mammals have finally come into their own. The thorough studies of Vernon Bailey on the mammalian fauna of New Mexico and Oregon, Lyon's *Mammals of Indiana*, Burt's *Mammals of Michigan*, and more recently, Hall's *Mammals of Nevada*, are all exemplary models. The present work of Ingles on the mammalian fauna of California is yet another in the current trend to treat the mammals of a specific state. The volume was written for the "student, for the aspiring naturalist, and for all others who want a better acquaintance with and knowledge of the interesting mammals of California." It is evident to one who carefully reads the book that the author has a first-hand knowledge of the mammals resident to California. The reviewer is heartily in accord with the idea that emphasis should be placed on species and that subspecies, in a state where so many occur, should be treated only in the keys.

The present volume starts with a brief introduction, a chapter on how to study mammals (which includes a discussion of measurements, range maps, life zones and habitats, the use of keys, etc.) and 209 pages devoted to the general description, habits and distribution of the various species occurring in California. A good appendix lists all California species and a discussion of collecting methods and the preparation of study skins. A suitable index is provided.

Dr. Ingles has compiled the volume with care. As a consequence there are few errors, some of which are inevitable in a work of this scope. A few statements need qualification. One might question whether mammals have really dominated the world (p. 1); the reviewer's garden would indicate that insects play the dominant role! The use of "sensitive snout" in a key is of questionable value to the student (p. 9). Since the opossum normally has but thirteen teats, it seems unlikely that "twenty-two young" ever occur in a litter (p. 24). Such a large litter may be born; all but thirteen are doomed for starvation. Is man the worst enemy of the bat (p. 43)? Do not man-made dwellings provide better shelter than bats had in earlier days? The statement that very little is known about the breeding habits of the weasel (p. 58) is not quite true. The gestation, growth of young and early life have been reported by several investigators. While the skunk has a good pelt, it does not bring "up to five dollars" (p. 71). For the past fifteen years the best pelts in the United States have not averaged more than a dollar or two. If flying squirrels can really "after gaining momentum on the earth, . . . leap into the air and glide up to limbs five or six feet above the ground" (p. 119), the author should enlarge on such observations and record them in more detail. The statement (p. 165) that the new-born young of *Neotoma fuscipes* weigh 130 grams at birth is obviously a misprint. Too much credence is given the ferret as a controller of rats (p. 183). The reviewer has had much experience with ferrets, and has yet to see an individual that would tackle a feral rat. Few Norway rats fall in the 1-1/2 pound category. Ingles apparently accepts the legend (p. 194) that a hungry man, lost in the woods, can resort to the inevitable porcupine. Why not a rabbit? The latter are always more abundant and as easily killed. Among measurements (p. 236) no mention is made of weight. Such is most desirable in determining age of many small mammals, and far more important than the variable ear measurements. Pigment in the hair does not occur in the medulla (p. 245) but rather in the cortex.

The illustrations are excellent and leave little to be desired. A critical reader might question whether the large mole and the shrew in Plate II were not posed individuals. If such, they should be labelled accordingly.

This volume was presumably designed for students and teachers of natural history on the west coast. It would be well, in future printings, to add pertinent references on the life history and ecology of the species treated, in addition to some general works on

mammals to supplement the book. The classification of California mammals (pp. 231-234) would be improved by listing all known subspecies. Professor Ingles has provided a source of information needed by students. He is to be commended for presenting a readable and authoritative volume for field zoologists of western United States.—W. J. HAMILTON, JR., Cornell University, Ithaca, N. Y.

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THE MAMMALS OF MICHIGAN. By Wililam H. Burt. University of Michigan Press, Ann Arbor, Michigan. 1946. 288 pages, 107 figs., 67 maps, and 13 colored plates. \$3.50.

Detailed information for the 67 kinds of mammals recorded as now or formerly living within the present boundaries of the state of Michigan is presented in this book. For the most species data on size and weight, description of external features, cranial and dental characters, distribution, economic status, and pertinent citations to the literature are included in the accounts. The series of line drawings and 13 color plates were done by Richard Philip Grossenheider. Two artificial keys (one for external characters and the other for skulls) to the mammals of Michigan precede the descriptive portion of the text. The drawings illustrating the key characters were prepared by Miss Grace Eager. The counties in which authenticated occurrences of each species are a matter of record are indicated on the state distribution map. The general distribution in North America of each species is shown on a smaller inset map. Other useful data, including measurements of carcass and skull, number of teeth, toes and mammae, the gestation period, litters per year, young per litter, longevity, home range in acres, and presence or absence of baculum are listed for each species in Table 4 of the Appendix.

In the introductory chapters of this book Burt has dealt rather briefly with earlier published accounts, the faunal position of Michigan mammals, the economic importance of mammals, adaptive radiation, home ranges and territories, populations, and collecting and preparing specimens. Nevertheless, the survey of the changes wrought within the state through interference by man could hardly be stated more forcibly. As the result of the cutting of forests, the draining of swamps and the plowing of land suitable habitats were destroyed for some of the native mammals, and for others more favorable conditions were created. Bison, elk, and caribou were eliminated by hunting. Elk, however, have been introduced and re-established in Otsego County. Moose are now restricted to Isle Royale and the Northern Peninsula. Effective conservation measures have again made white-tailed deer plentiful in Michigan. Of the predatory types that were once found within this state, the wolverine, marten, fisher, and cougar are probably gone. The timber wolf and the lynx have taken refuge on Isle Royale and the more inaccessible Upper Peninsula, while the black bear, river otter, and bobcat are being reduced by the cultivation of land, by trapping and by hunting.

On the other hand, Burt shows that the prairie mole, striped ground squirrel, prairie deer mouse, and cottontail and possibly also the fox squirrel have extended their ranges northward with the clearing of the land and now occur over most of the Lower Peninsula. The records indicate that the opossum was rarely encountered until about 1900 and now it is one of the commonest mammals in the southern four tiers of counties. On the basis of estimates furnished by the State Conservation Department, Burt has tabulated the quantity and value of both meat from game mammals and pelts from fur-bearers harvested in the 1941-1942 season. The total calculated value of these products is slightly less than five million dollars.

Although this book was written primarily to stimulate an interest in mammals by the public and to provide a text for courses in natural history given in high schools and colleges, the material presented therein will contribute to a better understanding of the basic requirements for the management of this natural resource.—REMINGTON KELLOGG, U. S. National Museum, Washington, D. C.



WILD MAMMALS OF VIRGINIA. By Charles O. Handley, Jr. and Clyde P. Patton. Commonwealth of Virginia: Commission of Game and Inland Fisheries, Richmond. 1947. vi + 220 pages, 103 figs. \$3.00.

The purpose of this interesting little book, as stated in the preface, "... is to put into the hands of the farmer, the hunter, the student, and the teacher, a simple, adequate reference that will help him fill in the numerous gaps in our knowledge." It is clearly a handbook for the amateur, and the authors have endeavored to make it interesting and at the same time scientifically accurate by dividing the contents into two major parts. The first, occupying 90 pages, is devoted to general discussions in a popular vein. The latter portion of 124 pages, treats the native and naturalized mammals from the standpoints of characteristics, distribution, and habitats. Photographs of most of the common species are given, and the distribution of all forms is shown by spot maps.

The first chapter is devoted to such preliminary considerations as the zoological position of mammals and remarks on taxonomic nomenclature. These subjects are treated briefly but adequately. Succeeding chapters discuss, in order, game mammals, furbearers, rodents, insectivorous mammals, marine forms, and "vanished" mammals. Although such an arrangement of subject matter is an artificial one, it is one likely to appeal to the average reader. These chapters contain miscellaneous and general information presented in a very entertaining and informal manner.

Preceding the systematic account of species are three short sections on (1) Natural Regions in Virginia, (2) Chicklist of Wild Mammals (which includes many unreported but expected species as well as extinct ones), and (3) a key to the orders of mammals that occur in the State. This key uses simple and conspicuous characters to separate the orders, except in the case of the Marsupalia, which is distinguished by the number of teeth. Some other character, such as the pouch, might have been better. Teeth are frequently difficult to count except in cleaned skulls.

The systematic treatment includes, under each order, simple keys to the Virginian species, and the individual specific accounts are subdivided into the following parts: Latin name, English name, type locality, distinguishing characteristics, measurements, general distribution, Virginia distribution, habitat, and remarks. A spot map is given for each form, and these serve to show how well the game animals have been reported and how poorly known are the bats, insectivores, and other small mammals. These accounts are regrettably abbreviated, and one would wish for a fuller treatment of habitat preferences and range within the State. It might be considered paradoxical that the type locality is cited, for the average reader of the book will not appreciate its significance, much less find it of any value.

There is a bibliography of 125 titles which lists the most important works bearing on Virginia mammalogy; and a satisfactory seven-page index.

One hesitates to criticize a book which was conscientiously prepared to meet an obvious need, and which is admittedly a preliminary contribution. There are, however, a few minor points which might be raised more as suggestions for possible future editions than as actual critiques of the book itself.

In preparing a volume which is published in the hope of stimulating more interest in a somewhat neglected field, it behooves the author to go further than merely state the need of more study and to mention a few points of interest. In the present volume, a section called "Studying Virginia Mammals" occupies two pages of print, one of which is devoted to remarks on how to catch glimpses of mammals in the field, and the other to outlining in brief the procedure of making study skins. It seems that detailed instructions on trapping and preparing mammals would have been very pertinent to the purpose of the book. Reference is made to a pamphlet on the subject, issued by the American Museum of Natural History, but one would think that in a book designed to assist the beginner, all possible concessions to completeness would be made. Some suggestions could have been offered in connection with methods in life history and ecological studies, which many amateurs are in a position to pursue. Unless specifically advised, few neophytic mammalogists would think to retain the stomachs, embryos, parasites, etc. or record specific information on habitats.



The "Natural Regions" depicted and discussed on page 91 are in reality natural geographic regions. While there are a few mammals whose ranges coincide with physiographic provinces, a better notion of natural life regions could be had by definition of Life Zones or Biotic Districts. Some mention is made of the effect of climate (rainfall) on mammals in producing local color and size variations, but this is the only approach to a discussion of ecology and distribution, and is regrettably short.

From a physical standpoint, the book is well made with a good quality paper and attractive format. Reproduction of the maps and plates is good, and typographical errors are very few. Occasionally a line of print is of a smaller size than the rest, but such cases are few and do not detract from the appearance.

The book will undoubtedly prove valuable to amateur naturalists as well as to mammalogists interested in the distribution and habitats of mammals in Virginia. Whether or not it will stimulate investigation and study by farmers, hunters, and students remains to be seen.—RICHARD L. HOFFMAN, Miller School of Biology, University of Virginia, Charlottesville.

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MAMMALS OF NORTH AMERICA. By Victor H. Cahalane. The Macmillan Co., New York. 1947. x+682 pages, illus., with drawings by Francis L. Jaques. \$7.50.

Among the many books now appearing about the mammals of the North American Continent, V. H. Cahalane's *Mammals of North America* should readily provide interesting information for all readers. Recognizing the vast amount of technical and semi-technical material that is available concerning his subject matter, the author has endeavored to present a book primarily for the layman. While some of Mr. Cahalane's methods (e.g., his descriptions of animal habits in "human" terms) may perhaps be considered juvenile, the book is not only a well-fitted reference for elementary courses in biology and zoology, but also does it provide a wealth of instruction for any reader uninitiated in the ways of animal life.

The actual descriptive material of the mammals comprises over 600 pages, and herein contained for the layman is ample coverage of the smaller mammals as well as the larger ones. The author has achieved a unique continuity by grouping into twenty chapters those mammals which are commonly associated with one another, e.g., *Original American Livestock* being devoted to the buffalo, muskox, bighorn sheep, and mountain goat; *The Wild Dogs*, to the coyote, foxes, and the wolf; *Chisel Teeth*, pocket gophers, spiny mouse, beavers, etc. A pertinent summary of the life and habits of each mammal is given, and also included are the names, both scientific and common, the general description, the distinguishing characteristics, and the distribution of each. Interest in each mammal is abetted by the adequate compiling from other authorities and further elucidated upon from the author's own personal observations and experiences.

Accompanying most of the descriptions of species is a black and white illustration. While colored plates, which often allow a more detailed study of the subject may be desired by some, still it is always advantageous to have something more than merely a mental picture.

Mr. Cahalane is to be complimented in his attempt to so satisfactorily bring to the reader such a vast amount of material. He himself acknowledges the great number of species of mammals that inhabit the North American Continent and the consequence of a one-volume limitation. His book, however, should prove of value not only to the layman but also to the student and the scientist. The bibliography contained in this volume is excellent, foremost of which are references to specific mammals, and it provides a ready reference from numerous sources for those who desire further and more specific study.—ACKER E. AND STANLEY P. YOUNG, Chevy Chase, Maryland.

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